

# **STREM**

## **Nanomaterials**

**Includes  
Surfactants  
and Ligands  
for Nano  
Synthesis**

### **High Surface Area Silica Nanoparticles**

**by Jean-Marie Basset and Pradeep Doggali**



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- Nanomaterials
- New Products
- Other Ligands
- Phosphorous Ligands and Compounds
- Photocatalysts
- PURATREM: High Purity Inorganics

# Glossary of Terms

<b>[α]<sub>D</sub></b>	.....	Specific rotation
<b>AAS</b>	.....	Atomic Absorption Standard
<b>ACS</b>	.....	Conforms to American Chemical Society specifications
<b>air sensitive</b>	.....	Product may chemically react with atmospheric oxygen or carbon dioxide at ambient conditions. Handle and store under an inert atmosphere of nitrogen or argon.
<b>amp</b>	.....	Ampouled
<b>b.p.</b>	.....	Boiling point in °C at 760mm, unless otherwise noted
<b>d.</b>	.....	Density
<b>dec.</b>	.....	Decomposes
<b>elec. gr.</b>	.....	Electronic Grade, suitable for electronic applications
<b>f.p.</b>	.....	Flash point in °F
<b>gran.</b>	.....	Granular
<b>heat sensitive</b>	.....	Product may chemically degrade if stored for prolonged periods of time at ambient temperatures or higher. Store at 5°C or lower.
<b>hydrate</b>	.....	Unspecified water content which may vary slightly from lot to lot
<b>hygroscopic</b>	.....	Product may absorb water if exposed to the atmosphere for prolonged periods of time (dependent on humidity and temperature). Handle and store under an inert atmosphere of nitrogen or argon.
<b>light sensitive</b>	.....	Product may chemically degrade if exposed to light
<b>liq.</b>	.....	Liquid
<b>m.p.</b>	.....	Melting point in °C
<b>moisture sensitive</b>	.....	Product may chemically react with water. Handle and store under an inert atmosphere of nitrogen or argon.
<b>NMR grade</b>	.....	Suitable as a Nuclear Magnetic Resonance reference standard
<b>optical grade</b>	.....	For optical applications
<b>powdr.</b>	.....	Powder
<b>primary standard</b>	.....	Used to prepare reference standards and standardize volumetric solutions
<b>PURATREM</b>	.....	Product has a minimum purity of 99.99% (metals basis)
<b>purified</b>	.....	A grade higher than technical, often used where there are no official standards
<b>P. Vol.</b>	.....	Pore volume
<b>pyrophoric</b>	.....	Product may spontaneously ignite if exposed to air at ambient conditions
<b>reagent</b>	.....	High purity material, generally used in the laboratory for detecting, measuring, examining or analyzing other substances
<b>REO</b>	.....	Rare Earth Oxides. Purity of a specific rare-earth metal expressed as a percentage of total rare-earths oxides.
<b>SA</b>	.....	Surface area
<b>store cold</b>	.....	Product should be stored at -18°C or 4°C, unless otherwise noted (see product details)
<b>subl.</b>	.....	Sublimes
<b>superconductor grade</b>	.....	A high purity, analyzed grade, suitable for preparing superconductors
<b>tech. gr.</b>	.....	Technical grade for general industrial use
<b>TLC</b>	.....	Suitable for Thin Layer Chromatography
<b>v.p.</b>	.....	Vapor pressure mm of Hg
<b>xtl.</b>	.....	Crystalline

## About Purity

<b>Chemical purity</b>	.....	is reported after the chemical name, e.g. Ruthenium carbonyl, 99%
<b>Metals purity</b>	.....	is reported in parentheses with the respective element, e.g. Gallium (III) bromide, anhydrous, granular (99.999%-Ga) PURATREM where 100% minus the metal purity is equal to the maximum allowable percentage of trace metal impurity

## High Surface Area Fibrous Silica Nanoparticles (KCC-1)

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### Introduction

Given the growing demand for silica materials for various applications including catalysis, drug delivery, bio sensing, liquid chromatography, coating & paints, optically active materials, as well as in cosmetics, much research has been carried out to control the shape, structure, and pore-size leading to various types of mesoporous silica materials. However, the performance, and therefore the applicability, of mesoporous silica has been hindered by the limitation in accessibility to the active sites within the porous structure for many reasons, such as clogging of the pores by the sintering of active metals and also by accumulation of the carbonaceous by products inside the pores or at the external surface of porous materials. The morphology of the mesoporous silica could also influence the way drugs gets encapsulated and their subsequent release. Therefore, development and fabrication of novel silica materials with unique morphology that leads to high performances, which results in super efficiency is imperative to meet the emerging applications.

KAUST's novel fibrous silica nanospheres (KCC-1)<sup>[1]</sup> offers a unique alternative shape, other than porosity, that has never before been seen in silica materials: a fibrous surface morphology arranged in three dimensional structure to form spheres. Unlike traditional pore-based silica, these nanospheres possess a fibrous structure that increases accessibility to most of the available surface area; this, for example, increases catalytic activity significantly. KCC-1 has been attracting the attention of researchers all over the world owing to its unique morphology and high surface area and therefore, making it ideal for use in a wide variety of catalytic reactions, sorbent and biological applications such as immobilization of enzymes and delivering DNAs.

A range of Nano catalysts synthesized using KCC-1 as a support have been showing excellent catalytic activity for various reactions of industrial importance. As a catalyst support/sorbent/carrier, KCC-1 has been demonstrating superior activity as compared to commercially available mesoporous silica materials such as MCM-41 and SBA-15. Some of these KCC-1 based materials and their corresponding reactions are included in Table.1.

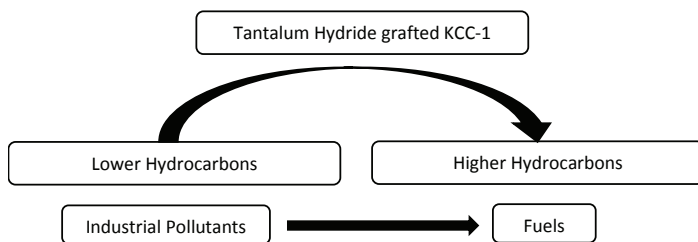
S.N	KCC-1 based material/catalyst/sorbent	Catalytic reaction/sorbent application/ carrier for DNAs and genes	Reference
1.	Tantalum hydride catalyst supported on KCC-1	Hydrometathesis of olefins	2
2.	Ruthenium (Ru) nanoparticles supported on KCC-1	Hydrogenolysis of Propane	3
3.	KCC-1 based silver nanocatalyst	Hydrogenation of dimethyl oxalate (DMO)	4
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**Table 1.**

Our group at catalysis research center (KCC) of KAUST has been working on catalytic applications using KCC-1 for different reactions. Successful attempts have been made in studying KCC-1 based catalysts for olefin and alkane metathesis, C-C Coupling, H<sub>2</sub> production from natural gas, oxidation reactions and photocatalytic water splitting. Our research work on above mentioned application using KCC-1 is briefly discussed.

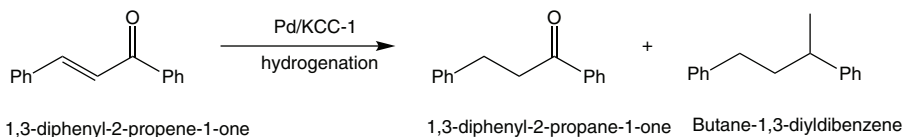
### I) Hydro-metathesis of olefins

Hydro-metathesis is a catalytic reaction of transition metal hydride, which in the presence of hydrogen catalyzes the direct conversion of olefins into alkanes having higher and lower numbers of carbon atoms. In this work, Tantalum hydride grafted on KCC-1 transforms an olefin in the presence of hydrogen at moderate temperatures into the expected corresponding alkane, and also transforms the same olefin into alkanes having a higher and lower number of carbon atoms. The catalytic hydro-metathesis of propylene (1:1 mixture of olefin and hydrogen) was performed and compared with 1-butene hydro-metathesis on a microreactor equipped with a stainless steel reactor at atmospheric pressure at 150°C. The reactions proceeded efficiently with 37–40% conversion of propylene and 48–51% of 1-butene. In the case of propylene, in addition to the expected hydrogenation product propane, butane (35–40%) and ethane (40%) were the major products formed, with methane, iso-butane, and pentanes as the minor products. In case of 1-butene, major products formed include butane, propane (47–61%) and hexanes (13–25%) whereas ethane, propylene, pentanes, and heptanes formed as minor products. Remarkably, in both cases catalyst possessed high stability and regeneration ability<sup>[2]</sup>. Graphical representation of the process is presented below.



### II) Hydrogenation of alkenes

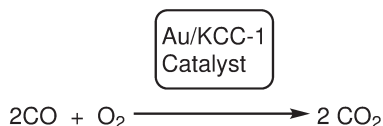
Hydrogenation of alkenes and  $\alpha,\beta$ -unsaturated carbonyl compounds have been studied using an efficient KCC-1 based catalyst (palladium nanoparticles supported on KCC-1). This resulted excellent yields of the corresponding products with very high chemo-selectivity in the case of  $\alpha,\beta$ -unsaturated carbonyl compounds. We have observed the superior performance of KCC-1 in comparison with commercial mesoporous silica supports like MCM-41 and SBA-15 under identical conditions. These results are attributed to superior accessibility of catalytically active sites along with high loading and excellent dispersion of palladium in case of KCC-1<sup>[10]</sup>.



### III) Influence of metal particle (Au nanoparticles) size on catalytic CO oxidation

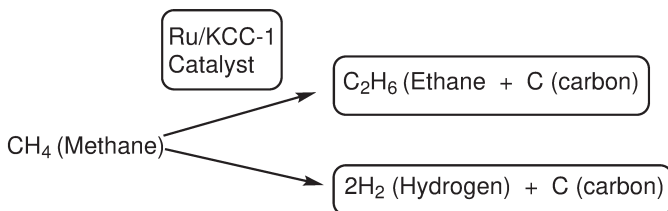
In order to study the possible advantage of using the fibrous nature of KCC-1, we synthesized gold nanoparticles (Au NPs) with different size and supporting them on KCC-1. The activity of the resulting catalysts was tested for CO oxidation reaction. It is evidenced by the HR-TEM studies that the size and the location of the Au NPs on the support observed to be dependent on the method of synthesis. The catalytic activity of the Au NPs proved to be size dependent. We have also observed that larger Au NPs of Au/KCC-1-NH<sub>2</sub> were not able to penetrate the pores of KCC-1 and showed only limited catalytic activity. In this study, it was possible to place highly dispersed Au NPs with uniform size inside the fibers of KCC-1-NH<sub>2</sub> by grafting HAuCl<sub>4</sub> on Au/KCC-1-NH<sub>2</sub> followed by reduction<sup>[14]</sup>.





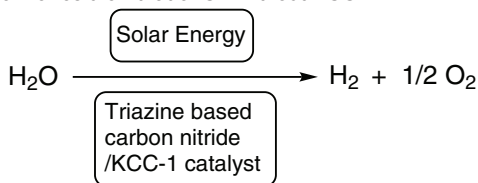
#### IV) Coupling of methane to ethane and hydrogen

We have developed a method to selectively produce hydrogen and ethane from methane by thermocatalytic decomposition of methane using Ru nanoparticles supported on Nano fibrous Silica (KCC-1) catalyst. These catalysts have been synthesized by post modification of KCC-1 with amine groups using APTS (3-aminopropyl triethoxysilane) followed by supporting nanoparticles on KCC-1. In this work, suitable temperatures and pressures have been found to produce a product having either hydrogen with solid carbon or ethane with solid carbon. The novelty of this approach also associated with the catalyst system that is efficient to produce the hydrogen and ethane as mentioned above with feed gas comprising less than 1000 ppm water. Also, the formation of hydrogen and ethane has not produced carbon dioxide (CO<sub>2</sub>) but a just carbon. Based on the structure of the carbon (formed in this reaction), it can have applications as carbon graphite/ carbon fiber/ carbon nanotube<sup>[15]</sup>.



#### V) Photocatalytic water splitting

We have also been successful in utilizing fibrous nature of KCC-1 for photocatalytic reactions. Triazine-based carbon nitride (CN) synthesis in the presence of KCC-1, resulted in favorable effects to advance photocatalytic stability. The photocatalyst synthesized using this approach yielded a HER photocatalyst with a significant AQE of  $22.1 \pm 3\%$  at 400 nm for solar to HER. The improved lifetime for the ground-state bleaching of the excited charge carriers was evidenced by time-resolved transient absorption spectroscopy. The synthesized CN/KCC-1 photocatalyst has been consistent with the higher photocatalytic performance than that of CN without KCC-1<sup>[16]</sup>.

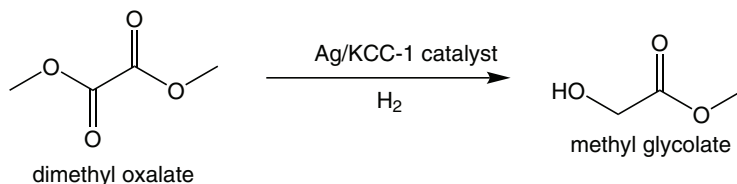


Experiments are also in progress to test KCC-1 for different industrially important reactions considering its superior performance as compared to conventional silica supports.

Several researchers all over the globe have successfully utilized KCC-1 for various applications after our discovery of KCC-1 in 2010. Therefore, work carried out by research groups from other institutions has been discussed to sum-up the highlights of some potential applications of KCC-1.

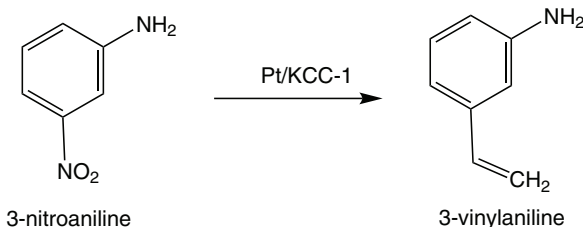
#### VI) Hydrogenation of dimethyl oxalate (DMO) to Methylene Glycol (MG)

Mengyao Ouyang et al. studied Ag/KCC-1 nanocatalyst for hydrogenation of dimethyl oxalate (DMO) to Methyl Glycolate (MG) and they compared the activity of Ag/KCC-1 with Ag/SBA-15 and Ag/MCM- 41. The results showed that dispersion of metals was completely dependent on the nature silica support used, which results in different dispersion and accessibility of active sites. Authors concluded that KCC-1 with hierarchical pore channels has higher accessible internal surface area and therefore displays high catalytic activity<sup>[4]</sup>.

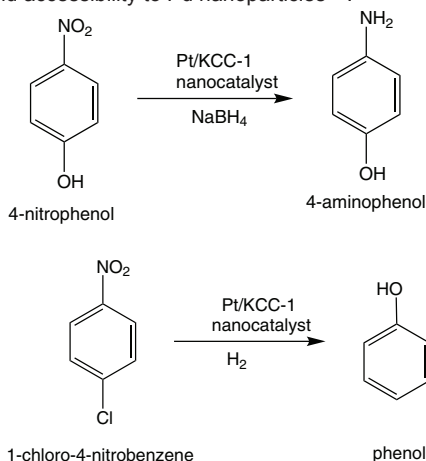


## VII) Hydrogenation of functionalized aromatic compounds

M. Dhiman et al. synthesized ultrasmall platinum (Pt) nanoparticles on PEI (polyethylenimine) functionalized KCC-1 (KCC-1-PEI/Pt) and studied their activity for hydrogenation of 3-nitrostyrene. Authors observed an extraordinary selectivity for the said reaction and Pt (1%) supported on PEI functionalized KCC-1 was found to be selective towards reduction to 3-vinylaniline. On the other hand, 10% and 5% Pt loaded on KCC-1-PEI demonstrated high activity and selectivity towards 3-ethylaniline. It was observed that among studied catalysts KCC-1-PEI/Pt (1%) was found to be an efficient catalyst for the hydrogenation of a variety of substituted aromatic compounds. From obtained results it was described, how selectivity can be tuned just by changing the particle size of Pt nanoparticles. In this study, most active sites were observed to be subnanometer particles and pseudo-single atoms of Pt <sup>[17]</sup>.



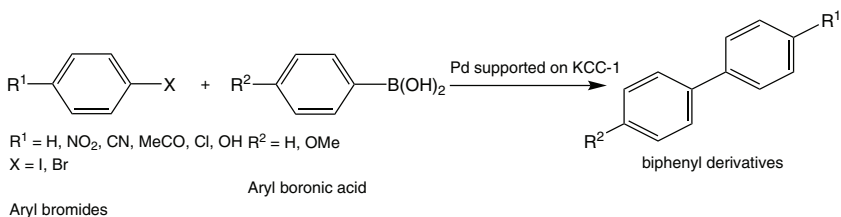
X. Le et al. investigated palladium supported KCC-1 catalyst for reduction of nitrophenols (4-NP) and hydrodechlorination of chlorophenols (4-CP). In order to synthesize catalysts, Pd precursor was added the functionalized KCC-1 followed by reduction with NaBH<sub>4</sub>. The Pd nanoparticles were well dispersed on fibers of KCC-1 and showed good catalytic activity for both the reactions. The higher catalytic activities was explained on the basis of morphological characteristics of the support which favors uniform dispersion and accessibility to Pd nanoparticles<sup>[18]</sup>.



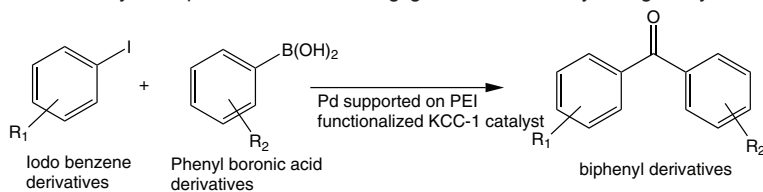
In another one of their studies, X. Le et al. have explored magnetically retrievable core-shell catalyst Pd/Fe<sub>3</sub>O<sub>4</sub>@SiO<sub>2</sub>@KCC-1. The catalytic performance of the synthesized catalyst was determined by reduction reaction of 4-nitrophenol (4-NP) to 4-aminophenol (4-AP). The reduction rate was more for Pd/Fe<sub>3</sub>O<sub>4</sub>@SiO<sub>2</sub>@KCC-1 as compared to Pd on other supports. The catalyst was also tested for Suzuki coupling reaction and found to have good stability and reusability (up to five cycles)<sup>[19]</sup>. M. Dhiman et al.





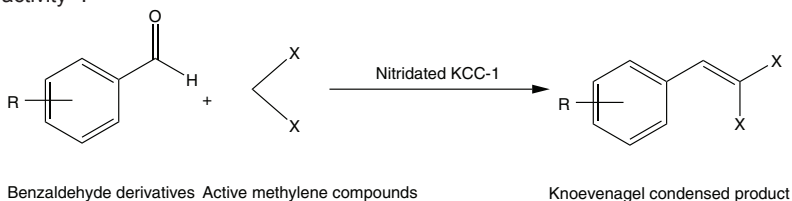


P. Gautam et al. synthesized palladium nanoparticles (Pd NPs) supported on KCC-1 and developed an economically viable and sustainable protocol for the carbonylative Suzuki–Miyaura cross coupling reaction. Pd nano particles supported on KCC-1 demonstrates the turnover number (TON) 28- times and a turnover frequency (TOF) 51-times greater than the best Palladium supported catalyst reported for the carbonylative cross-coupling between 4-iodoanisole and phenylboronic acid. Catalysts tested in this study could be recycled up to ten times with negligible loss in activity till eighth cycle<sup>[23]</sup>.



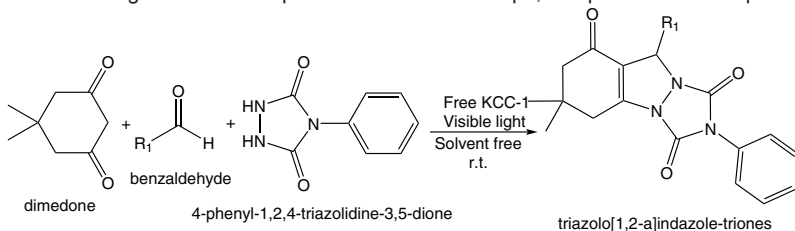
## IX) Knoevenagel condensation

M.Bouhrara et al. synthesized Nitridated KCC-1 (solid base) by ammonolysis under a flow of ammonia (NH<sub>3</sub>). It was found that the synthesized catalyst is highly active for Knoevenagel condensation reactions of different aldehydes. Tested catalysts in this research work were active for the transesterification of esters with a wide range of alcohols compared to the reported catalysts. Authors explained the improvement in activity by the presence of both basic (amines) and acidic (silanols) sites and more importantly excellent accessibility of these sites in case of KCC-1. The unique structure of KCC-1 assists the substrates to easily penetrate and interact with basic amine and helps in improving the catalytic activity<sup>[6]</sup>.

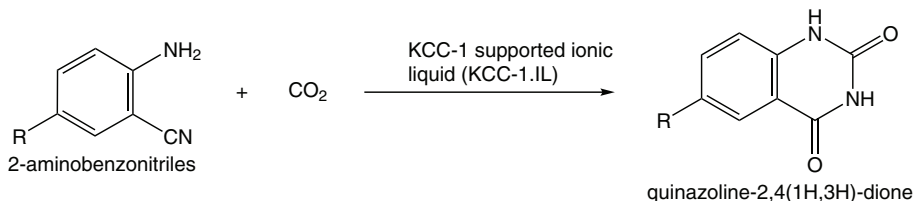


## X) Synthesizing different organic compounds

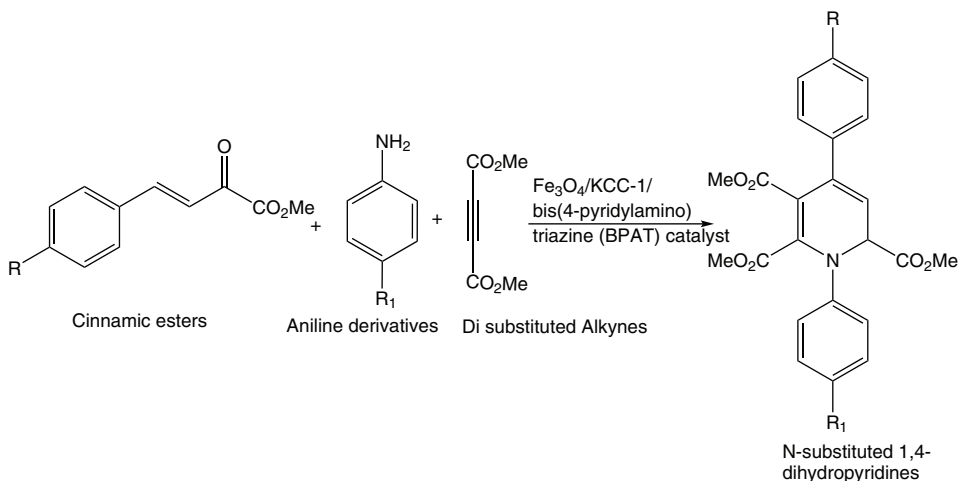
S.M. Sadeghzadeh explored KCC-1 based catalysts for construction of different organic compounds. Author reported a green and efficient method for synthesis of various triazolo [1,2-a]indazole-triones using KCC-1 catalyst at room temperature under solvent free conditions by visible light. Nano-SiO<sub>2</sub>, MCM-41, SBA-15 were also tested for synthesis of triazolo [1,2-a]indazole-triones using the same conditions. It was observed that the yields of the desired product was fair to good with Nano-SiO<sub>2</sub>, MCM-41, SBA-15. However, KCC-1 shows excellent yields for the same reaction. Non-negligible activity observed using KCC-1 was explained based on its shape, composition and morphology<sup>[10]</sup>.



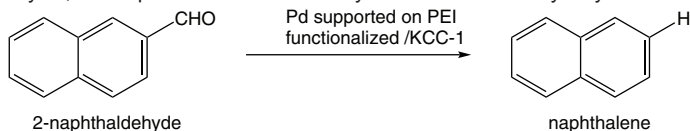
In a different study, S.M. Sadeghzadeh synthesized ionic liquid functionalized KCC-1 and their activity was tested for the synthesis of quinazoline-2,4 (1H, 3H)-diones from CO<sub>2</sub> and 2-aminobenzonitriles under mild conditions. Author compared the catalytic performance of ionic liquid functionalized KCC-1 and literature reported catalysts. Results in this study clearly indicate that the synthesized catalysts show good to excellent yields at lower temperature with small amount of catalyst, lower pressure of carbon dioxide and shorter reaction time. The synthesis was shown to be green, low-cost and was effective for the development of other materials<sup>[24]</sup>.



The author also investigated Fe<sub>3</sub>O<sub>4</sub>/KCC-1/BPAT MNPs core-shell nanocomposite for the synthesis of N-substituted 1,4-dihydropyridines with excellent yield under mild reaction condition. It was found that the studied catalyst was non-toxic, green and economically viable and recyclable for the synthesis of N-substituted 1,4-dihydropyridines<sup>[25]</sup>.

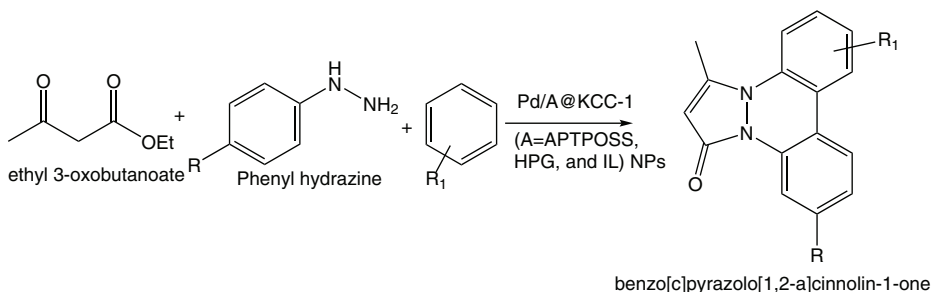


P. K. Kundu et al. studied KCC-1-PEI/Pd catalysts for decarbonylation of aldehydes, wherein they developed an efficient heterogeneous catalytic protocol for the decarbonylation of a variety of aldehydes with complete conversion to products. By doing this, authors have found an easy way for product purification (without chromatography) using KCC-1-PEI/Pd catalyst. The developed method in this study not only limited to aromatic aldehydes, but the decarbonylation of hetero aromatic, alkane, and alkenylaldehyde derivatives. Authors found that the studied catalyst have excellent recyclability even after eightcycles, which proves the sustainability of the studied catalyst system<sup>[26]</sup>.



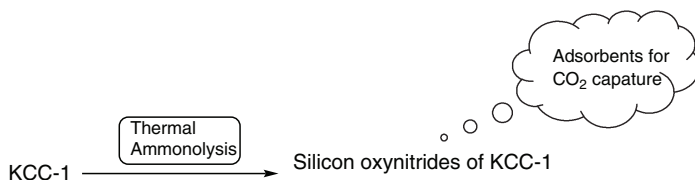
S. Sadeghzadeh synthesized palladium nanoparticles (Pd NPs) dispersed on KCC-1 functionalized with different groups such as APTPOSS@KCC-1, hyperbranched polyglycerol@KCC-1 (HPG@KCC-1), and ionic liquid@KCC-1 (IL@KCC-1). These catalysts are evaluated for synthesis of benzo[c]pyrazolo[1,2-a]cinnolin-1-one. It was observed that APTPOSS@KCC-1 displayed good catalytic

reaction and also exhibited excellent reusability in the catalytic reaction. The high activity of APTPOSS functionalized KCC-1 was attributed to its high accessibility and minimum aggregation. Also its tolerance to leaching of the nanoparticles<sup>[27]</sup>.



## XI) Adsorbent for CO<sub>2</sub> capture

U. Patil et al. studied the use of silicon oxynitrides as adsorbents for CO<sub>2</sub> capture. In this investigation authors synthesized three series of functionalized materials based on KCC-1, SBA-15 and MCM-41 with Si-NH<sub>2</sub> groups in a single step process via thermal ammonolysis. Authors demonstrate that studied materials overcome several limitations associated with conventional aminegrafted mesoporous silica. Adsorbents prepared by ammonolysis shows good CO<sub>2</sub> capture capacity, faster adsorption-desorption kinetics as well as effective regeneration and reuse. Also the studied materials demonstrate excellent thermal and mechanical stability<sup>[28]</sup>. Graphical representation of the process is presented below.

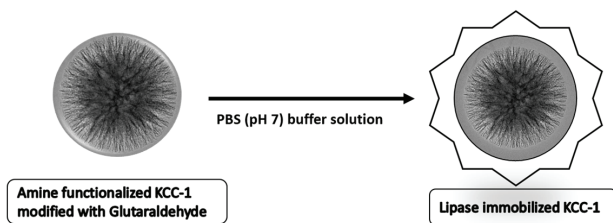


B. Singh et al. synthesized KCC-1 based hybrid materials functionalized by different amine molecules using physisorption and covalent attachment. Synthesized materials were tested for their CO<sub>2</sub> capture capacity. Among the studied materials, the tetraethylene pentamine (TEPA) based KCC-1 (KCC-1-TEPAads) showed superior capacity in comparison with MCM-41 in terms of textural stability, CO<sub>2</sub> capture capacity, rate of adsorption as well as thermal stability. KCC-1-TEPAads demonstrates the adsorption capacity of 91.5 mmol g<sup>-1</sup>, whereas MCM-41-TEPAads CO<sub>2</sub> capture capacity was observed to be only 73.1 mmol g<sup>-1</sup>. These results clearly indicate the superior stability of the KCC-1-based sorbents as compared to the conventional mesoporous materials<sup>[5]</sup>. Graphical representation of the above mentioned process is shown below.

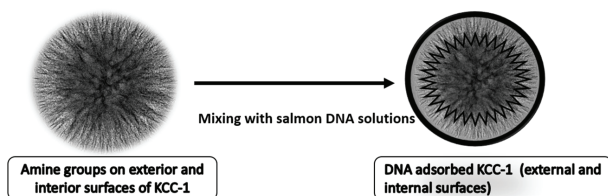


## XII) Biological applications like immobilization of enzymes and DNA adsorption studies

Zafar Ali et al. also studied the immobilization of lipase on KCC-1. Author's method of synthesis, activation, and optimization of immobilization conditions, produced better resistance to temperature and pH inactivation as compared to the free lipase. Therefore, it widened the reaction pH and temperature regions, with the optimum pH and temperature of 7.5 and 40°C, respectively. The immobilized Lipase i.e. *Candida Rugosa* (ICRL) showed above 81% of the initial activity even after 28 days. Also 80% activity after 8 repeated cycles. Authors also demonstrated the ICRL improved storage stability, reusability as well as 700 U/g of protein as immobilization efficiency<sup>[29]</sup>. Graphical representation of Immobilization of enzyme on KCC-1 is shown below.

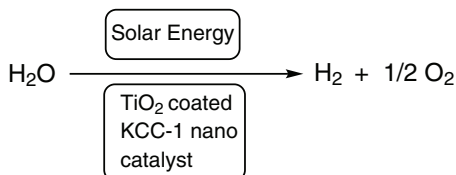


Xiaoxi Huang et al. performed DNA adsorption studies on a series of KCC-1- and MCM-41-based nanomaterials that are functionalized with organoamine groups. Authors observed higher adsorption capacities for KCC-1 based materials as compared to MCM-41 based nanomaterials. It was explained that DNA adsorption reaches saturation once the outer surfaces of the MCM-41 nanoparticles are occupied by the DNA molecules, leaving their inner channel spaces to play negligible role in the adsorption of DNA molecules. However, due to the unique fibrous morphology, KCC-1-based nanomaterials absorb DNAs efficiently both on their external and internal surfaces. Cellular toxicity tests performed in this study demonstrates the biocompatibility of KCC-1<sup>[12]</sup>. Graphical representation of DNA adsorbed KCC-1 is shown below.

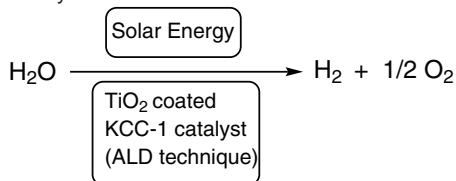


### XIII) Photo catalysis

Bayal et al. also reported a new method to fabricate  $\text{TiO}_2$  on the fibers of KCC-1. The synthesized KCC-1/ $\text{TiO}_2$  photocatalyst showed a very high yield of  $\text{H}_2$  (26.4 mmolh<sup>-1</sup>g<sup>-1</sup>  $\text{TiO}_2$ ) in presence of UV light. The yield reported in this research study was one of the best reported so far for photocatalytic  $\text{H}_2$  generation. In addition, authors do not observe decrease in photocatalytic activity of KCC-1/ $\text{TiO}_2$ , unlike conventional mesoporous silica materials and this effect was attributed to open morphology of KCC-1<sup>[30]</sup>.

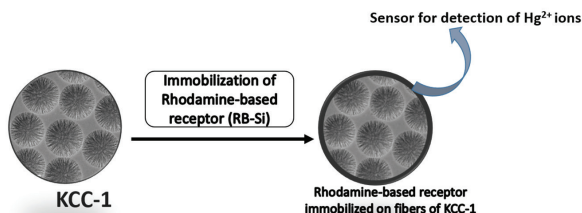


R. Singh et al. designed and synthesized KCC-1 based photo catalysts by coating  $\text{TiO}_2$  on fibers of KCC-1 using atomic layer deposition (ALD). Catalysts developed by authors showed superior catalytic activity for photocatalytic dye degradation in comparison to MCM-41 and SBA-15 based  $\text{TiO}_2$  catalysts synthesized with aid of ALD as well as literature reported silica-supported  $\text{TiO}_2$  catalysts. Authors have described the advantages of KCC-1/ $\text{TiO}_2$  catalysts over MCM-41 and SBA-15 based  $\text{TiO}_2$ . Some of these include uniform and conformal coating, less reduction in surface, enhanced light harvesting properties and better accessibility of active sites<sup>[13]</sup>.



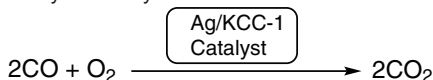
#### XIV) Optical sensing properties

KCC-1 has been also explored as sensor with optical sensing properties and is used for detection of  $\text{Hg}^{2+}$  detection with very good selectivity, and sensitivity. The sensor was developed by immobilizing the rhodamine-based receptor (RB-Si) within the fibers of KCC-1. Authors observed that spirolactam ring opening of the rhodamine groups are the main reason for the fluorescence enhancement responses of RB-KCC-1 and obtained a detection limit of  $9.05 \times 10^{-7}$ . Based on the results obtained authors conclude that the synthesized materials are potential candidates for the detection and effective removal of  $\text{Hg}^{2+}$  in biological, environmental, and industrial fields<sup>[31]</sup>. The below figure indicates the Graphical representation of RB-Si Immobilized KCC-1 acted as a sensor for the detection of  $\text{Hg}^{+2}$  ions.



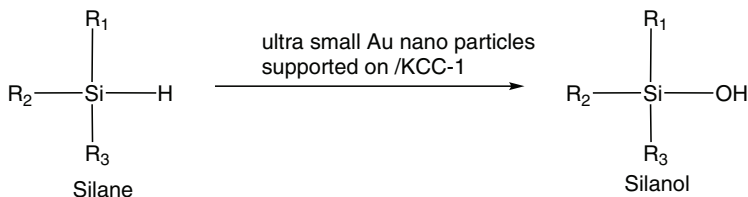
#### XV) Effect of pore structure of silica on CO oxidation activity

J. Xu et al. studied the CO oxidation reaction using different Ag supported on mesoporous supports such as MCM-41, SBA-15 and KCC-1. Authors observed that the morphology of the supports influence the dispersion of Ag nanoparticles, consequently shows difference in catalytic activity. It was mentioned that when KCC-1 was used, the migration and agglomeration of Ag particles can be effectively hindered by the open access mesopores. Authors therefore conclude that in comparison with SBA-15 and MCM-41, KCC-1 shows very high catalytic activity<sup>[8]</sup>.



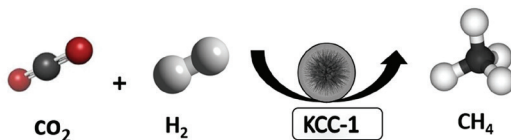
#### XVI) Oxidation of organosilanes to silanols

M. Dhiman et al. reported ultrasmall and pseudo single atoms of gold supported on KCC-1 for the oxidation of organosilanes to silanols with high Turnover Number (TON), which is nearly half a million (591,000) for dimethylphenyl silane as a model substrate). The Extraordinary catalytic activity and stability in this study was attributed to dispersion of ultrasmall nanoparticles and pseudo-single atoms of Au as well as  $\text{Au}^{\delta+}$  species on fibers of KCC-1. This oxidation was carried out only at  $45^\circ\text{C}$  using water as an oxidant and hydrogen was observed to be the by-product in this study. Authors also mention that, it was possible to easily separate Au based KCC-1 catalyst and they are stable for several cycles. These results clearly indicates the reusability of catalyst<sup>[32]</sup>.



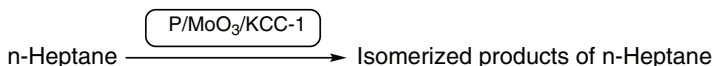
#### XVII) $\text{CO}_2$ methanation

Hamid et al. studied the catalytic activity of KCC-1 for  $\text{CO}_2$  methanation and found that KCC-1 is a probable candidate for the examined reaction as compared to MCM-41. The high activity of KCC-1 was attributed to the presence of abundant oxygen vacancy facilitating the  $\text{CO}_2$  adsorption/dissociation. With the help of IR studies, it was also explained that KCC-1 has significantly higher basicity in addition to oxygen vacancy than that of MCM-41. These two properties of the catalysts were explained as reasons for improved catalytic performance of the catalyst. KCC-1 in this research work show good stability throughout 90 h of reaction due to the resistance towards Ostwald ripening<sup>[7]</sup>. Graphical representation of  $\text{CO}_2$  methanation using KCC-1 is presented below.



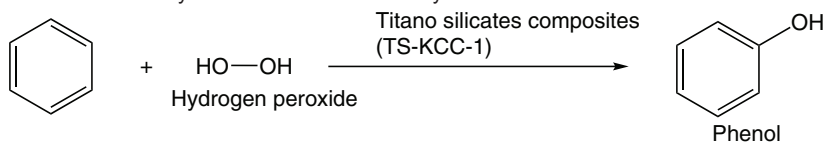
#### XVIII) n-Heptane isomerization

Fatah et al. synthesized Molybdenum oxide ( $\text{MoO}_3$ ) supported KCC-1 and phosphorus (P) loaded on  $\text{MoO}_3/\text{KCC-1}$  ( $\text{P}/\text{MoO}_3/\text{KCC-1}$ ) and studied its activity for n-Heptane isomerization. Synthesis was carried out by mixing the  $\text{MoO}_3$  and KCC-1 powder in a ball mill equipment. For doing this, an agate container having  $300 \text{ cm}^3$  volume and six-piece of 20 mm diameter agate ball (weight of approximately 11 g each) were used. Authors found a slight change in the morphology after the addition of  $\text{MoO}_3$  and modification with  $\text{H}_3\text{PO}_4$ . It was also observed  $\text{MoO}_3/\text{KCC-1}$  shows excellent catalytic activity for n-heptane isomerization. This was attributed to the high amount and high accessibility of the active sites as well as the high dispersion of  $\text{MoO}_3$ <sup>[33]</sup>. Graphical representation of the process is presented below.



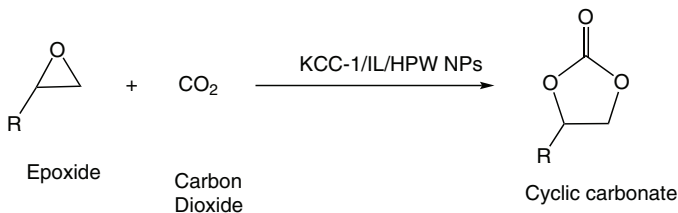
#### XIX) Benzene hydroxylation and 1-hexene epoxidation reactions

Yang et al. prepared nanosized monodispersed amphiphilic titanasilicate composite ( $\text{TS-1@KCC-1}$ ) materials, which exhibited superior thermal stability as well as catalytic activity. These surface active titanasilicates were evaluated for their activity in benzene hydroxylation and 1-hexene epoxidation reactions. They observed that  $\text{Rh}(\text{OH})_3$  species supported  $\text{TS-1@KCC-1}$  exhibited higher catalytic activity in benzene hydroxylation with hydrogen peroxide under Pickering Interface Catalysis (PIC) in comparison with phase-boundary catalysis (PBC). The PIC reaction system in this study demonstrates excellent chemical stability and reasonable reusability.<sup>[34]</sup>



#### XX) Synthesis of cyclic carbonate from carbon dioxide and epoxides

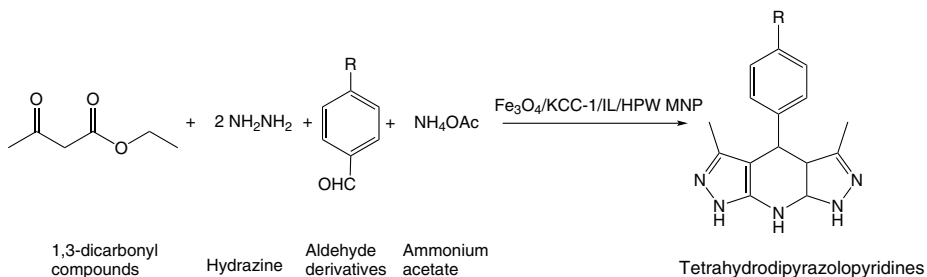
S.M. Sadeghzadeh also studied the KCC-1 supported heteropolyacid-based ionic liquid ( $\text{KCC-1/IL/HPW}$ ) for the synthesis of cyclic carbonate from carbon dioxide and epoxides under mild conditions. Authors observed increase in catalytic efficiency of  $\text{IL/HPW}$  after immobilization onto KCC-1 NPs and  $\text{KCC-1/IL/HPW}$  NPs are found to be recovered from the reaction mixture during the work-up procedure. Also the recycled catalyst was reused for ten consecutive cycles and observed to be active without any significant loss in catalytic activity. The developed method of synthesis in this study indicate a green and low-cost protocol for making heteropolyacid-based catalysts and is also promising for developing similar type of materials<sup>[35]</sup>.



#### XXI) Synthesis of tetrahydropyrazolo pyridines

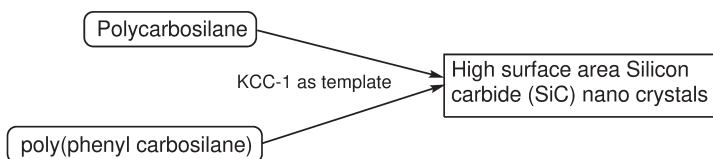
Using the developed heteropolyacid-based ionic liquid ( $\text{KCC-1/IL/HPW}$ ) catalyst S.M. Sadeghzadeh also investigated the synthesis of tetrahydropyrazolo pyridines. Catalyst was found to be active for the studied reaction and also it was possible to recover and reuse it several times without any significant decrease in activity and selectivity. The high activity of the catalyst was attributed to high accessibility of active sites available with KCC-1 based catalyst<sup>[36]</sup>.





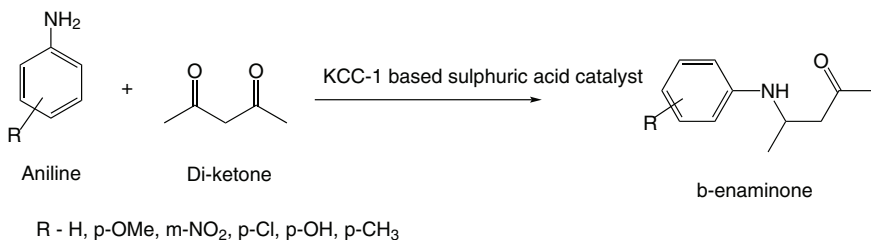
## XXII) Synthesis of high surface area Silicon carbides (SiC)

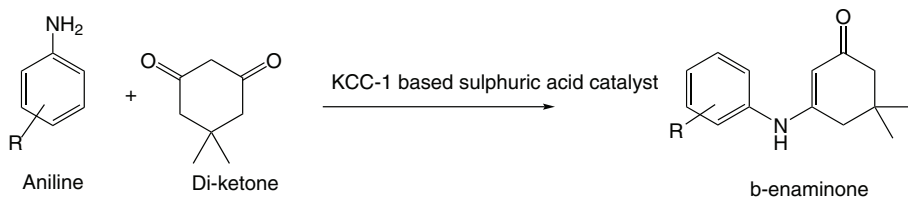
Eunjin Jung et al. made an attempt to make high-surface area SiC spheres by the nano casting technology using a KCC-1 as a template. Polycarbosilane and poly(phenyl carbosilane) were used as the precursor for silicon carbide and it was possible to obtain hollow spheres by the inversion of a template structure. In this work, poly (phenyl carbosilane) worked as a binding agent due to its higher molecular weight. Fibrous structure of KCC-1 was obtained for hollow spheres of silicon carbides. The resulting fibrous hollow spheres possessed SiC nano crystals and also shows 407 m<sup>2</sup>/g BET surface area<sup>[37]</sup>. Graphical representation of the process that describes the synthesis of high surface area Silicon carbides (SiC) is shown below.



## XXIII) Synthesis of β-enaminones

Z. N. Siddiqui et al. developed an efficient protocol for the preparation of β-enaminones using KCC-1 sulphuric acid catalyst. Synthesis of KCC-1 sulfuric acid (KCC-1-SA) was carried out by dispersing KCC-1 (1.0 g) in CH<sub>2</sub>Cl<sub>2</sub> (10 mL) in a flask. This was achieved by first dissolving chlorosulfonic acid (8 mmol) in CH<sub>2</sub>Cl<sub>2</sub> (10 mL) and the resulting solution was added to the KCC-1 suspension through a constant-pressure dropping funnel under stirring for around 30 min at room temperature. After this addition, the resulting mixture was stirred for another 30 min at room temperature. The obtained brown solid was collected by filtration and it was washed with ether (50 mL). Procedure was concluded with a drying step at room temperature. Authors carried out the reactions under thermal solvent-free conditions and after a few minutes they obtained excellent yields. It was concluded that the amount of catalyst used is very low and the followed methodology that is environmentally benign in comparison with H<sub>2</sub>SO<sub>4</sub>, in terms of the amount, hazardous nature and reaction conditions. It was possible to recover the catalyst and is recyclable up to seven cycles without much loss in activity<sup>[38]</sup>.

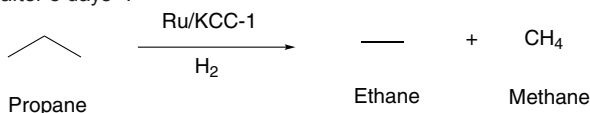




R - H, p-OMe, m-NO<sub>2</sub>, m-NO<sub>2</sub>, p-Cl, p-OH, p-CH<sub>3</sub>

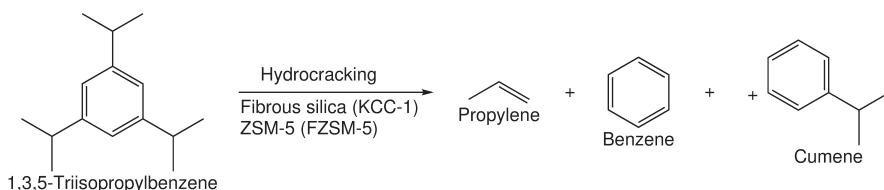
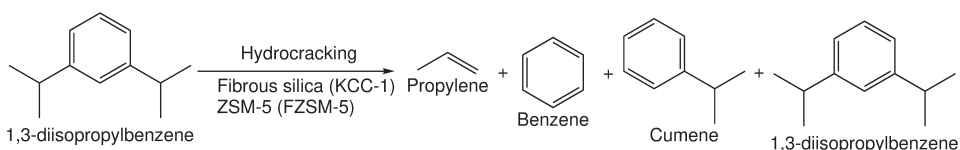
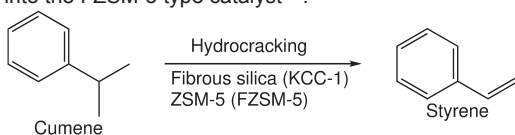
#### XXIV) Hydrogenolysis of Alkanes

Fihri et al. studied Ru nanoparticle supported on KCC-1 for the hydrogenolysis of propane and ethane. It was observed from the TEM images that Ru nanoparticles are fully loaded on fibers of KCC-1. Authors proved that KCC-1 showed better catalytic performance as compared to conventional mesoporous silica materials such as MCM-41 and SBA-15. This examination was carried out by loading comparable Ru content on aforementioned supports and testing under identical conditions. It was also explained that the superior catalytic activity of KCC-1 based catalyst is attributed to high accessibility of Ru supported on KCC-1. In addition, high activity of Ru/KCC-1 catalyst was explained through HR-TEM studies. Authors mention that in case of Ru/KCC-1 hexagonal shaped nanoparticles were present having several corners and sharp edges and these possess reactive atoms with lowest coordination numbers. Catalyst based on KCC-1 was observed to be stable with excellent lifetime. Deactivation was not observed even after 8 days<sup>[3]</sup>.



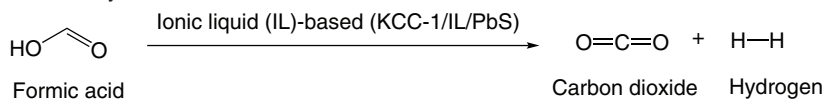
#### XXV) Cumene hydrocracking

M. L. Firmansyah et al. prepared ZSM-5 zeolite with KCC-1 by combining a microemulsion technique with zeolite seed-assisted crystallization. The resulting material (FZSM-5) possessed very good physicochemical properties such as high surface area, fibrous morphology and strong acid sites. Authors explained that the cumene hydrocracking activity of the material could be attributed to the large number of active sites as well as their high accessibility. High dispersion of the metal particle was also observed, which was mainly due to the large surface area of the FZSM-5 type catalyst. The catalytic activity for cumene hydrocracking and EB dehydrogenation was enhanced by the protonation and introduction of Pt into the FZSM-5 type catalyst<sup>[39]</sup>.



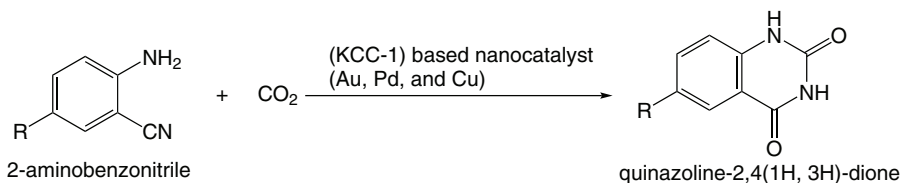
## XXVI) Dehydrogenation of aqueous solutions of HCOOH/HCOONa

S.M. Sadeghzadeh synthesized a novel PbS (lead sulphide) containing ionic liquid IL-based KCC-1 catalysts (KCC-1/IL/PbS) and studied their catalytic applications in dehydrogenation of aqueous solutions of HCOOH/HCOONa to H<sub>2</sub> and CO<sub>2</sub> gas. It was found that the activity was due to dendritic fibrous morphology of the KCC-1 as well as the synergistic effect between KCC-1/IL and the small PbS NPs. Catalysts investigated in this study could be recovered and reused at least ten times with no decrease in activity<sup>[40]</sup>.



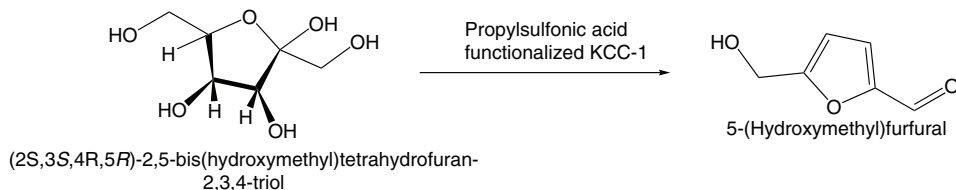
## XXVII) Spider catalyst for the synthesis of quinazoline-2,4(1H,3H)-diones

S.M. Sadeghzadeh synthesized multi-carboxylic hyperbranched polyglycerol groups (HPG) functionalized KCC-1 and nanocatalysts based on noble metal (Au, Pd, and Cu) were developed with the functionalized KCC-1. These resulting catalysts observed to be having ultrasmall size and monodisperse particles with uniform distribution, and high loading capacity. With the help of synthesized catalysts, an economically viable and green protocol was developed for reaction of CO<sub>2</sub> with 2-aminobenzonitrile to obtain quinazoline-2,4(1H, 3H)-diones. Authors examined the impact of HPG by synthesizing catalyst with HPG functionalization and without HPG functionalization i.e KCC-1/HPG/X (X = Au, Pd, Cu) and KCC-1/X (X = Au, Pd, Cu). It was observed that the amount of motionless nanoparticles in KCC-1/HPG/X were about twice that in KCC-1/X. From the results, the effectiveness of HPG functionalization on KCC-1 was demonstrated<sup>[41]</sup>.



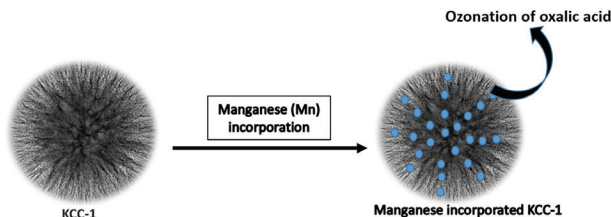
## XXVIII) Production of 5 hydroxymethylfurfural (HMF)

N. Chermahini et al. functionalized KCC-1 with propylsulfonic acid groups (Pr-SO<sub>3</sub>H) and investigated resulting catalysts efficiency for the production of 5 hydroxymethylfurfural (HMF) by the dehydration of fructose. Authors achieved 67.71% yield and 68.32% selectivity for the HMF at a 99.11% fructose conversion. Although the acid loading on the catalyst surface was low, the results observed in this study are better as compared to the reported studies. It was explained that the catalyst was reusable and can be synthesized by an environmentally friendly process for the heterogeneous catalytic manufacture of 5-HMF<sup>[42]</sup>.

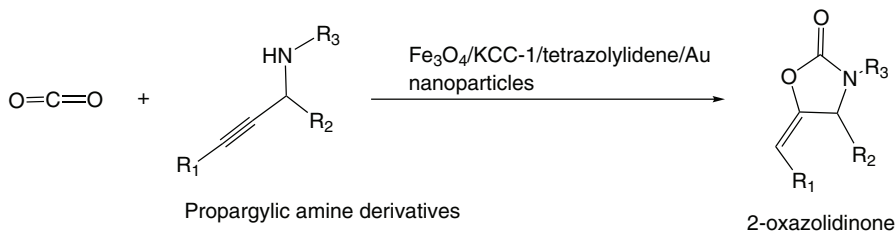


### XXIX) Ozonation of oxalic acid

S. Afzala et al. investigated the Manganese incorporated fibrous silica nanosphere (MnOx-0.013/KCC-1) for ozonation of oxalic acid. Synthesized catalysts show excellent activity and stability with minimum Mn leaching in comparison to MnOx loaded on MCM-41. The high catalytic activity of studied catalysts was attributed to the generation of hydroxyl radical. Authors mentioned that surface hydroxyl groups observed with the help of phosphates and ATR-FTIR were found to be active sites<sup>[43]</sup>. Graphical representation of Mn loaded KCC-1 used for ozonation of oxalic acid is shown below.

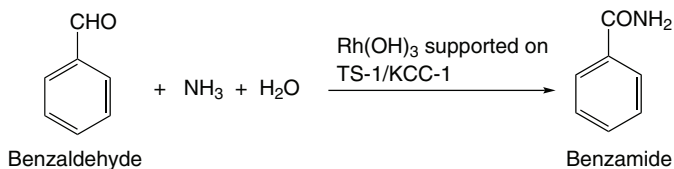


S.M. Sadeghzadeh studied gold (III) phosphorus complex containing HPG-based KCC-1 and tested its catalytic activity for the cyclization of propargylic amines with CO<sub>2</sub> to provide 2-oxazolidinones. It was observed that hot filtration tests and selective catalyst poison examinations showed the presence of soluble Au species during the reaction process. However, recovery studies demonstrated that no significant decrease has occurred in the activity and metal content of recovered KCC-1/IL/Au. On the other hand catalysts were able to be recovered and reused at least ten times with no loss in activity and selectivity. Through the obtained results it was concluded that superior effectiveness of HPG@KCC-1/PPh<sub>3</sub>/Au nanocatalyst was attributed to isolated HPG units incorporated in the fibers of KCC-1, which could control the mechanistic aspects through preventing the formation of agglomerated gold (III) phosphorus complex and stabilization of active catalytic gold species<sup>[44]</sup>.



### XXX) One-pot synthesis of benzamide

Hong-gen Peng et al. Synthesized a core-shell material consisting of KCC-1 and encapsulated TS-1 zeolite (Si/Ti=40) in a microemulsion system. Rh(OH)<sub>3</sub> species were supported on KCC-1 and the resulting bifunctional Rh(OH)<sub>3</sub>/TS-1@KCC-1 catalyst was used for obtaining primary amides from aldehyde, NH<sub>3</sub> and H<sub>2</sub>O<sub>2</sub> through one-pot ammoximation and rearrangement (benzamide from benzaldehyde). Authors explained that Titanosilicates are potential candidates for catalyzing the oxidation of NH<sub>3</sub> with H<sub>2</sub>O<sub>2</sub> to yield the hydroxylamine intermediate. The formed intermediate again reacts with aldehydes or ketones via non-catalytic oximation to produce oximes. In this study, the Rh(OH)<sub>3</sub> species are considered to be the catalytic sites for the rearrangement of aldehyde oximes to amides. The synthesized TS-1@KCC-1 catalyst was also found to have superior hydrothermal and mechanical stability and is a robust support for dispersing and stabilizing the Rh(OH)<sub>3</sub> species<sup>[45]</sup>.

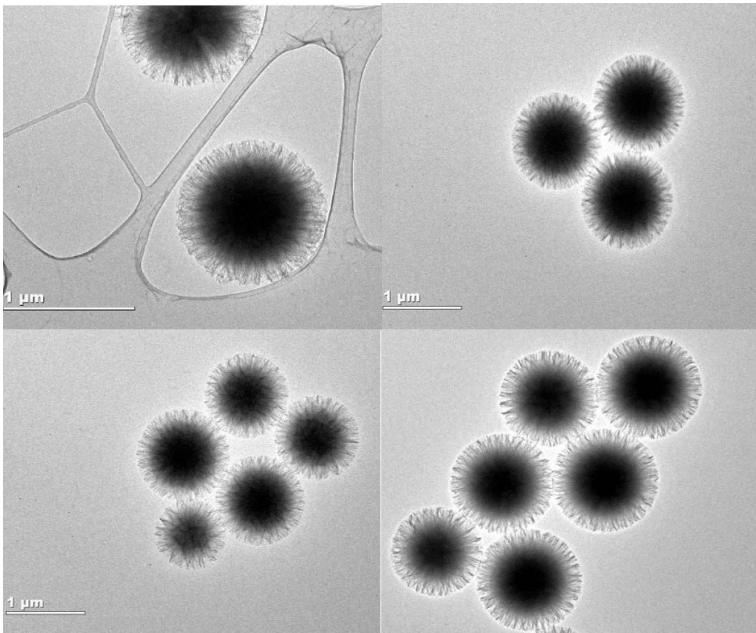


**Catalog Products of KCC-1**

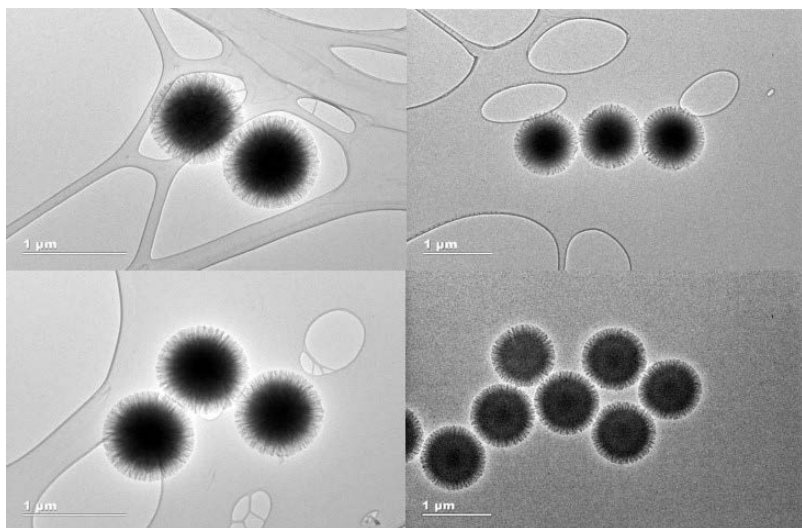
Different grades of KCC-1 products have been included in the catalogue and these products based on their varied properties can have different applications in catalysis, paints& coatings, cosmetics and drug delivery. Table.1 indicates the particle size, specific surface area and pore volume of different grades of KCC-1. Figure (1-6) show the Transition Electron Microscopy (TEM) images of KCC-1 product portfolio.

Category	Grade	Particle size (nm)	Spec.Surface Area (m <sup>2</sup> /g)	Pore Volume (cm <sup>3</sup> /g)
Large	KCC-1 L1	~900-1000	~ 700	~1.40
	KCC-1 L2	~900-1000	~ 600	~1.20
	KCC-1 L3	~900-1000	~ 550	~0.80
Medium	KCC-1 M1	~400-450	~ 400	~0.50
	KCC-1 M2	~300-350	~ 600	~0.60
Small	KCC-1 S1	~ 130-190	~380	~ 0.80

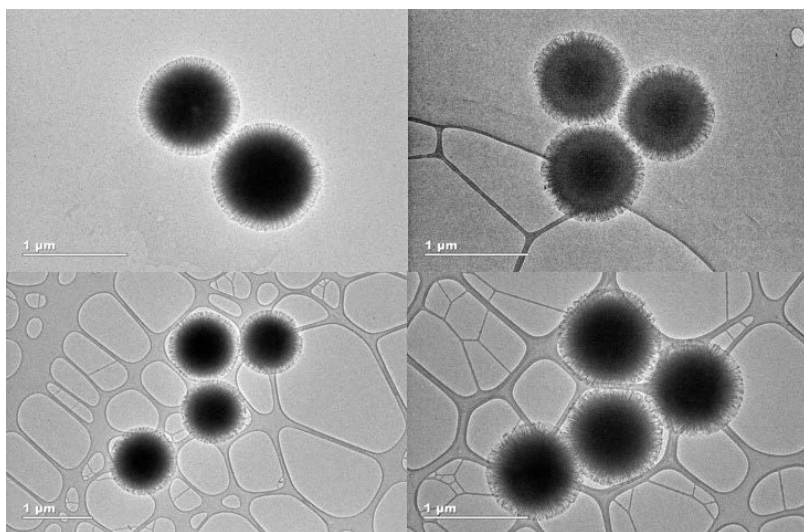
**Table.2:** Summary of properties of KCC-1 product portfolio



**Figure.1:** Transition Electron Microscopy images of KCC-1 (L1 grade)

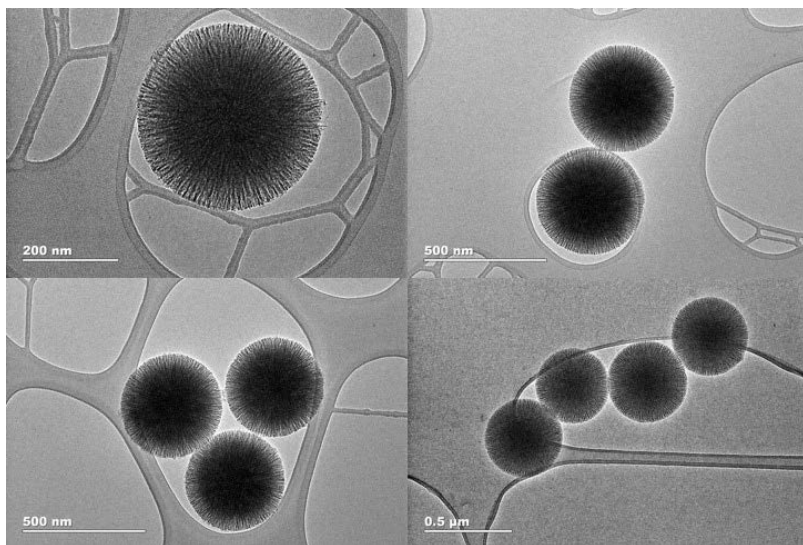


**Figure.2:** Transition Electron Microscopy images of KCC-1 (L2 grade)

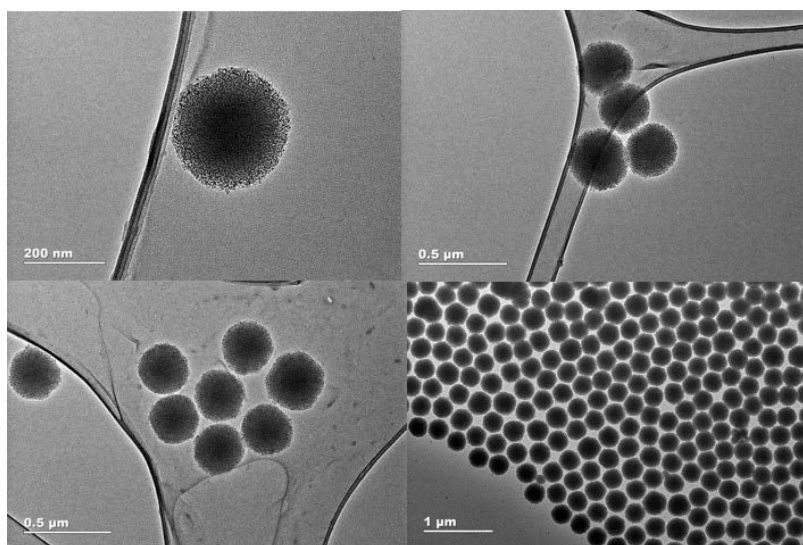


**Figure 3:** Transition Electron Microscopy images of KCC-1 (L3 grade)

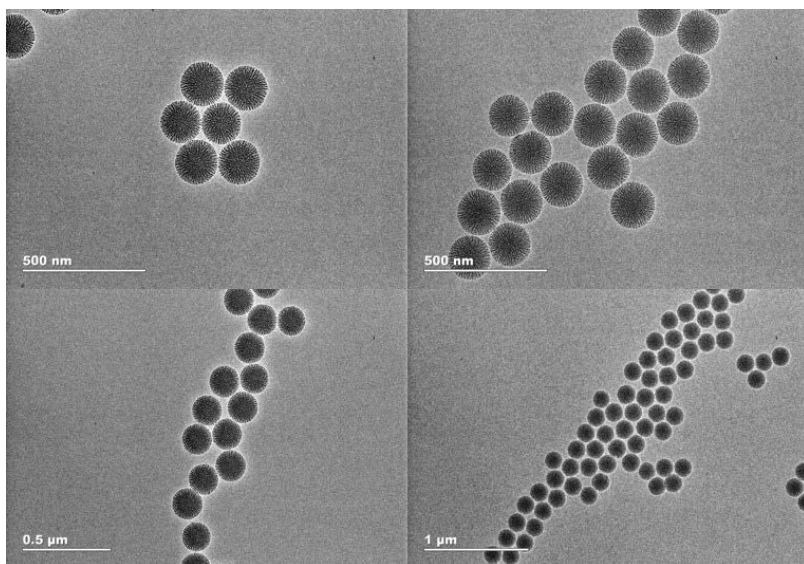




**Figure 4:** Transition Electron Microscopy images of KCC-1 (M1 grade)



**Figure 5:** Transition Electron Microscopy images of KCC-1 (M2 grade)



**Figure 6:** Transition Electron Microscopy images of KCC-1 (S1 grade)

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## NANOMATERIALS - ALUMINUM (Compounds)

<b>13-1400</b>	<b>Aluminum oxide nanopowder (1344-28-1)</b>	50g
	Al <sub>2</sub> O <sub>3</sub> ; FW: 101.96; white powdr.	250g
	Note: Average Particle Size (APS): 3 nm	

**Specific Surface Area (BET):** ≤275 m<sup>2</sup>/g; **True Density:** 3.9 g/cc; **Crystallite Size:** Amorphous;  
**Mean Aggregate Size:** 1.5 µm; **Average Pore Diameter:** 28Å; **Loss on Ignition:** 2.1%;  
**Total Pore Volume:** ≥0.15 cc/g; **Al Content (Based on Metal):** >99.8%; **Bulk Density:** 0.5 g/cc

<b>13-1410</b>	<b>Aluminum oxide nanopowder, 99.9% (1344-28-1)</b>	50g
<b>NEW</b>	Al <sub>2</sub> O <sub>3</sub> ; FW: 101.96; white powdr.; SA: >15 m <sup>2</sup> /g; d. 3.9	
	Note: Average Particle Size (APS) <80nm	

## NANOMATERIALS - CADMIUM (Compounds)

<b>StremDots™ Quantum Dots (1306-24-7)</b>	5ml
<i>air sensitive, (store cold)</i>	25ml

Note: Cadmium selenide StremDots™ quantum dot (core) kit components. See page 58

<b>48-1011</b>	<b>Cadmium selenide StremDots™ quantum dot (CdSe core), 50umol/L in hexanes,</b>
HAZ	<b>525nm peak emission (1306-24-7)</b> CdSe; orange liq.

<b>48-1017</b>	<b>Cadmium selenide StremDots™ quantum dot (CdSe core), 50umol/L in hexanes,</b>
HAZ	<b>550nm peak emission (1306-24-7)</b> CdSe; red-orange liq.

<b>48-1023</b>	<b>Cadmium selenide StremDots™ quantum dot (CdSe core), 50umol/L in hexanes,</b>
HAZ	<b>575nm peak emission (1306-24-7)</b> CdSe; red liq.

<b>48-1030</b>	<b>Cadmium selenide StremDots™ quantum dot (CdSe core), 50umol/L in hexanes,</b>
HAZ	<b>600nm peak emission (1306-24-7)</b> red liq.

<b>48-1035</b>	<b>Cadmium selenide StremDots™ quantum dot (CdSe core), 50umol/L in hexanes,</b>
HAZ	<b>625nm peak emission (1306-24-7)</b> red liq.

<b>96-0800</b>	<b>Cadmium selenide StremDots™ quantum dot (CdSe core) kit, 50umol/L in hexanes,</b>
	<b>525-625nm peak emissions (1306-24-7)</b>
	See page 58

<b>StremDots™ Quantum Rods (1306-24-7)</b>	0.5ml
<i>(store cold)</i>	2ml

Store at 2-8°C in dark under inert atmosphere. Do not freeze. Stable for >12 months

Note: Cadmium selenide/cadmium sulfide StremDots™ quantum rod kit components. See page 58

<b>48-1053</b>	<b>Cadmium selenide/cadmium sulfide StremDots™ quantum rod</b>
HAZ	<b>(CdSe/CdS elongated core/shell), 5 mg/ml in hexanes, 560nm peak emission (1306-24-7)</b>
	CdSe/CdS; dispersed, yellow solution; <i>(store cold)</i>

<b>48-1056</b>	<b>Cadmium selenide/cadmium sulfide StremDots™ quantum rod</b>
HAZ	<b>(CdSe/CdS elongated core/shell), 5 mg/ml in hexanes, 590nm peak emission (1306-24-7)</b>
	CdSe/CdS; dispersed, orange solution; <i>(store cold)</i>

<b>48-1059</b>	<b>Cadmium selenide/cadmium sulfide StremDots™ quantum rod</b>
HAZ	<b>(CdSe/CdS elongated core/shell), 5 mg/ml in hexanes, 620nm peak emission (1306-24-7)</b>
	CdSe/CdS; dispersed, red solution; <i>(store cold)</i>

<b>96-0813</b>	<b>Cadmium selenide/cadmium sulfide StremDots™ quantum rod kit</b>
	<b>(CdSe/CdS elongated core/shell), 5 mg/ml in hexanes, 560nm, 590nm,</b>
	<b>620nm peak emissions (1306-24-7)</b>
	See page 58

## NANOMATERIALS - CADMIUM (Compounds)

### CdSe/ZnS - Solid Quantum Dots

Note: Each product below is a group of highly purified CdSe/ZnS quantum dots in solid form. The surface ligand is octadecylamine. The quantum dots can be dispersed in most organic solvents such as toluene, chloroform, and hexane. These quantum dots are specifically designed as emitters for optoelectronic applications such as LEDs.

10mg  
50mg

**48-1618**      **Cadmium selenide/Zinc sulfide quantum dots in solid form, Emission peak: 520nm,**  
HAZ              **FWHM <35nm, QY >50%**  
orange to red pwdr.

Technical Note:

1. See 48-1614 (page 25)

**48-1620**      **Cadmium selenide/Zinc sulfide quantum dots in solid form, Emission peak: 560nm,**  
HAZ              **FWHM <35nm, QY >50%**  
orange pwdr.

Technical Note:

1. See 48-1614 (page 25)

**48-1622**      **Cadmium selenide/Zinc sulfide quantum dots in solid form, Emission peak: 600nm,**  
HAZ              **FWHM <25nm, QY >50%**  
red pwdr.

Technical Note:

1. See 48-1614 (page 25)

**48-1624**      **Cadmium selenide/Zinc sulfide quantum dots in solid form, Emission peak: 630nm,**  
HAZ              **FWHM <25nm, QY >50%**  
red pwdr.

Technical Note:

1. See 48-1614 (page 25)

### CdSe/ZnS - Solid Quantum Dots with Amine in water

Note: A water-soluble CdS/ZnS or CdSSe/ZnS core/shell quantum dots with amphiphilic polymer and PEG coating. Reactive group is an amine.

2nmole  
10nmole

**48-1666**      **Cadmium selenide/Zinc sulfide core/shell quantum dots with Amine in water**  
HAZ              **Emission peak: 580 nm FWHM <25nm QY>50%**  
orange liq

Technical Note:

1. See 48-1658 (page 26)

**48-1668**      **Cadmium selenide/Zinc sulfide core/shell quantum dots with Amine in water**  
HAZ              **Emission peak: 620 nm FWHM <25nm QY>50%**  
red liq.

Technical Note:

1. See 48-1658 (page 26)

### CdSe/ZnS - Solid Quantum Dots with carboxylic acid in water

Note: A water-soluble CdSe/ZnS core/shell quantum dots with amphiphilic polymer and PEG coating. Reactive group is a carboxylic acid.

4nmole  
20nmole

**48-1638**      **Cadmium selenide/Zinc sulfide core/shell quantum dots with carboxylic acid in water**  
HAZ              **Emission peak: 580 nm FWHM <25nm QY>50%**  
orange liq.

Technical Note:

1. See 48-1630 (page 26)

**48-1640**      **Cadmium selenide/Zinc sulfide core/shell quantum dots with carboxylic acid in water**  
HAZ              **Emission peak: 620 nm FWHM <25nm QY>50%**  
red liq.

Technical Note:

1. See 48-1630 (page 26)



## NANOMATERIALS - CADMIUM (Compounds)

### CdSe/ZnS - Solid Quantum Dots with PEG in water

2nmole

Note: A water-soluble CdSe/ZnS core/shell quantum dots with amphiphilic polymer and PEG coating. Reactive group is a carboxylic acid.

10nmole

**48-1652** Cadmium selenide/Zinc sulfide core/shell quantum dots with PEG in water  
HAZ Emission peak: 580 nm FWHM <25nm QY>50%  
orange liq.

Technical Note:

1. See 48-1644 (page 27)

**48-1654** Cadmium selenide/Zinc sulfide core/shell quantum dots with PEG in water  
HAZ Emission peak: 620 nm FWHM <25nm QY>50%  
red liq.

Technical Note:

1. See 48-1644 (page 27)

### CdSSe/ZnS - Solid Quantum Dots

10mg

Note: Group of highly purified CdSSe/ZnS quantum dots in solid form. The surface ligand is oleic acid. The quantum dots can be dispersed in most organic solvents such as toluene, chloroform, and hexane. These quantum dots are specifically designed as emitters for optoelectronic applications such as LEDs.

50mg

**48-1602** Cadmium sulfide selenide/Zinc sulfide quantum dots in solid form  
HAZ Emission peak: 450nm, FWHM <35nm, QY >50%  
yellow pwdr.

**48-1604** Cadmium sulfide selenide/Zinc sulfide quantum dots in solid form  
HAZ Emission peak: 490nm, FWHM <35nm, QY >50%  
green pwdr.

**48-1606** Cadmium sulfide selenide/Zinc sulfide quantum dots in solid form  
HAZ Emission peak: 540nm, FWHM <35nm, QY >50%  
orange pwdr.

**48-1608** Cadmium sulfide selenide/Zinc sulfide quantum dots in solid form  
HAZ Emission peak: 600nm, FWHM <35nm, QY >50%  
red pwdr.

**48-1610** Cadmium sulfide selenide/Zinc sulfide quantum dots in solid form  
HAZ Emission peak: 630nm, FWHM <35nm, QY >50%  
red pwdr.

**48-1612** Cadmium sulfide selenide/Zinc sulfide quantum dots in solid form  
HAZ Emission peak: 665nm, FWHM <35nm, QY >50%  
brown pwdr.

### CdSSe/ZnS - Solid Quantum Dots with Amine in water

2nmole

Note: A water-soluble CdS/ZnS or CdSSe/ZnS core/shell quantum dots with amphiphilic polymer and PEG coating. Reactive group is an amine.

10nmole

**48-1662** Cadmium sulfide selenide/Zinc sulfide core/shell quantum dots with Amine in water  
HAZ Emission peak: 490 nm FWHM <35nm QY>50%  
yellow liq

Technical Note:

1. See 48-1658 (page 26)

**48-1664** Cadmium sulfide selenide/Zinc sulfide core/shell quantum dots with Amine in water  
HAZ Emission peak: 525 nm FWHM <35nm QY>50%  
yellow-green liq

Technical Note:

1. See 48-1658 (page 26)

**48-1670** Cadmium sulfide selenide/Zinc sulfide core/shell quantum dots with Amine in water  
HAZ Emission peak: 665 nm FWHM <35nm QY>50%  
dark red liq.

Technical Note:

1. See 48-1644 (page 27)

## NANOMATERIALS - CADMIUM (Compounds)

### CdSSe/ZnS - Solid Quantum Dots with carboxylic acid in water

4nmole

Note: A water-soluble CdSSe/ZnS core/shell quantum dots with amphiphilic polymer and PEG coating.

20nmole

Reactive group is a carboxylic acid.

**48-1634**

HAZ

**Cadmium sulfide selenide/Zinc sulfide core/shell quantum dots with carboxylic acid in water Emission peak: 490 nm FWHM <35nm QY>50%**  
yellow liq.

Technical Note:

1. See 48-1630 (page 26)

**48-1636**

HAZ

**Cadmium sulfide selenide/Zinc sulfide core/shell quantum dots with carboxylic acid in water Emission peak: 525 nm FWHM <35nm QY>50%**  
yellow-green liq.

Technical Note:

1. See 48-1630 (page 26)

**48-1642**

HAZ

**Cadmium sulfide selenide/Zinc sulfide core/shell quantum dots with carboxylic acid in water Emission peak: 665 nm FWHM <35nm QY>50%**  
dark red liq.

Technical Note:

1. See 48-1630 (page 26)

### CdSSe/ZnS - Solid Quantum Dots with PEG in water

2nmole

Note: A water-soluble CdSSe/ZnS core/shell quantum dots with amphiphilic polymer and PEG coating.

10nmole

Reactive group is a carboxylic acid.

**48-1648**

HAZ

**Cadmium sulfide selenide/Zinc sulfide core/shell quantum dots with PEG in water Emission peak: 490 nm FWHM <35nm QY>50%**  
yellow liq.

Technical Note:

1. See 48-1644 (page 27)

**48-1650**

HAZ

**Cadmium sulfide selenide/Zinc sulfide core/shell quantum dots with PEG in water Emission peak: 525 nm FWHM <35nm QY>50%**  
yellow-green liq.

Technical Note:

1. See 48-1644 (page 27)

**48-1656**

HAZ

**Cadmium sulfide selenide/Zinc sulfide core/shell quantum dots with PEG in water Emission peak: 665 nm FWHM <35nm QY>50%**  
dark red liq.

Technical Note:

1. See 48-1644 (page 27)

### CdS/ZnS - Solid Quantum Dots

10mg

50mg

**48-1614**

HAZ

**Cadmium sulfide/Zinc sulfide quantum dots in solid form, Emission peak: 400nm, FWHM <35nm, QY >50%**  
white pwdr.

Technical Note:

1. Group of highly purified CdS/Zns or CdSe/ZnS quantum dots in solid form. The surface ligand is octadecylamine. The quantum dots can be dispersed in most organic solvents such as toluene, chloroform, and hexane. These quantum dots are specifically designed as emitters for optoelectronic applications such as LEDs.

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## NANOMATERIALS - CADMIUM (Compounds)

### CdS/ZnS - Solid Quantum Dots

10mg  
50mg

**48-1616** Cadmium sulfide/Zinc sulfide quantum dots in solid form, Emission peak: 420nm,  
HAZ FWHM <35nm, QY >50%  
yellow powdr.

Technical Note:

1. See 48-1614 (page 25)

### CdS/ZnS - Solid Quantum Dots with Amine in water

2nmole  
10nmole

Note: A water-soluble CdS/ZnS or CdSSe/Zn core shell quantum dots with amphiphilic polymer and PEG coating. Reactive group is an amine.

**48-1658** Cadmium sulfide/Zinc sulfide core/shell quantum dots with Amine in water  
HAZ Emission peak: 400 nm FWHM <35nm QY>50%  
light yellow liq.

Technical Notes:

1. Zeta potential of QSA is from -20mV to +10 mV.
2. Organic layers consist of a monolayer of oleic acid/octadecylamine, a monolayer of amphiphilic polymer, and a monolayer of PEG.
3. Total thickness of organic layers is ~6 nm.
4. The hydrodynamic size of the QDs is about 12-14 nm larger than their inorganic core size as measured by TEM.
5. QSA is very stable in most buffer solutions in the pH range of 5-10, and can survive autoclaving processes of 121°C for 30 mins.
6. Amine density is low due to the long PEG chain.

References:

1. *Small*, **2009**, 5, 235

**48-1660** Cadmium sulfide/Zinc sulfide core/shell quantum dots with Amine in water  
HAZ Emission peak: 450 nm FWHM <35nm QY>50%  
yellow liq.

Technical Note:

1. See 48-1658 (page 26)

### CdS/ZnS - Solid Quantum Dots with carboxylic acid in water

4nmole  
20nmole

Note: A water-soluble CdS/ZnS core/shell quantum dots with amphiphilic polymer and PEG coating. Reactive group is a carboxylic acid

**48-1630** Cadmium sulfide/Zinc sulfide core/shell quantum dots with carboxylic acid in water  
HAZ Emission peak: 400 nm FWHM <35nm QY>50%  
light yellow liq.

Technical Notes:

1. Zeta potential of QSA is from -30mV to -50 mV.
2. Organic layers consist of a monolayer of oleic acid/octadecylamine and a monolayer of amphiphilic polymer.
3. Total thickness of organic layers is ~4 nm.
4. The hydrodynamic size of the QDs is about 8-10 nm larger than their inorganic core size as measured by TEM.
5. QSH is very stable in most buffer solutions in the pH range of 5-10, and can survive autoclaving processes of 121°C for 30 mins.

References:

1. *Small*, **2009**, 5, 235

**48-1632** Cadmium sulfide/Zinc sulfide core/shell quantum dots with carboxylic acid in water  
HAZ Emission peak: 450 nm FWHM <35nm QY>50%  
yellow liq.

Technical Note:

1. See 48-1630 (page 26)

## NANOMATERIALS - CADMIUM (Compounds)

### CdS/ZnS - Solid Quantum Dots with PEG in water

Note: A water-soluble alloy CdS<sub>Se</sub>/ZnS or CdSe/Zn core/shell quantum dots with amphiphilic polymer. 2nmole  
10nmole  
Their reactive group is a carboxylic acid.

**48-1644** Cadmium sulfide/Zinc sulfide core/shell quantum dots with PEG in water  
HAZ **Emission peak: 400 nm FWHM <35nm QY>50%**  
light yellow liq.

#### Technical Notes:

1. Zeta potential of QSA is from -30mV to -50 mV.
2. Total thickness of organic layers is ~4 nm.
3. The organic layers consist of a monolayer of oleic acid/octadecylamine and s monolayer of amphiphilic polymer.
4. The hydrodynamic size of the quantum dots is about 8-10 nm larger than their inorganic core size as measured by TEM.
5. The product is stable in most buffer solutions in the pH range of 5-10.

**48-1646** Cadmium sulfide/Zinc sulfide core/shell quantum dots with PEG in water  
HAZ **Emission peak: 450 nm FWHM <35nm QY>50%**  
yellow liq.

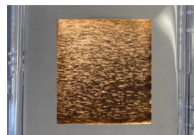
#### Technical Note:

1. See 48-1644 (page 27)

## NANOMATERIALS - CARBON (Elemental Forms)

### Carbon, Graphene

**06-0274** Graphene film, monolayer, on copper foil (1cm x 1cm)  
(1034343-98-0)  
C; foil



2pcs

100% coverage, >95% single atomic layer

Average grain (crystal/domain) size: >~100 micron

Average sheet resistance (on non-conductive substrate): 400 Ω/sq (+/- 200 Ω/sq)

Average transmission: T >96% (on transparent substrate, i.e. ~4% lower than substrate T)

**06-0310** Graphene film, monolayer, on Si/SiO<sub>2</sub> wafer (1cm x1cm), by CVD  
(1034343-98-0)  
C; FW: 12.011; wafer

1pc

**06-0323** Graphene oxide (0.8-1.2nm thick x 1-15 microns wide, made by the  
Staudenmaier Method)  
black powdr.; SA: 5-10 m<sup>2</sup>/g

250mg  
1g

**06-2545** Graphene oxide (4mg/ml water  
dispersion) (1034343-98-0)  
yellow-brown liq. dispersion

50ml  
250ml

#### Physical Properties:

*Form:* Dispersion of graphene oxide sheets; *Sheet dimension:* Variable; *Color:* Yellow-brown; *Dispersibility:* Polar solvents;  
*Solvent:* Water; *pH:* 2.2-2.5; *Concentration:* 4 mg/mL; *Monolayer content (measured in 0.5 mg/mL):* >95%\*

\*Note: 4 mg/mL tends to agglomerate the GO flakes and dilution followed by slight sonication is required in order to obtain a higher percentage of monolayer flakes

**Elemental Analysis:** (sample preparation: 2g of 4 wt% GO in water were dried under vacuum at 60°C overnight)

**Carbon:** 49-56%; **Hydrogen:** 0-1%; **Nitrogen:** 0-1%; **Oxygen:** 41-50%; **Sulfur:** 0-2%

#### Quality Control:

Amount of residue on evaporation

pH control

Elemental analysis

**Applications:** Graphene/polymer composite materials, batteries, biomedical, solar cells, supercapacitors, support for metallic catalysts, low permeability materials, biosensors, multifunctional materials, graphene research

#### References:

1. *J. Mater. Chem.*, **2011**, 21, 9762.
2. *Environ. Sci. Technol.*, **2013**, 47, 3715.
3. *Phys. Chem. Chem. Phys.*, **2013**, 15, 2321.

**06-2530** Graphene oxide (4mg/ml water dispersion) - low Mn. (1034343-98-0)  
C; brown liq.  
**NEW** Note: Diameter: 5-30 micron flakes.

100ml  
500ml

# NANOMATERIALS - CARBON (Elemental Forms)

## Carbon, Graphene

<b>06-2550</b>	<b>Graphene oxide, reduced</b> (1034343-98-0) black powdr.	250mg 1g
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### Physical Properties:

*Form:* powder; *Reduction method:* chemically reduced; *Sheet dimension:* variable; *Color:* black; *Solubility:* insoluble; *Dispersability:* <0.1 mg/mL in NMP, DMF, DMSO; *Humidity (Karl Fisher, TGA):* 3.7-4.2%; *Electrical conductivity:* 666,7 S/m (measured in a 20 nm film thickness); *BET surface area:* 422.69 - 499.85 m<sup>2</sup>/g; *Density:* 1.91 g/cm<sup>3</sup>

**Elemental Analysis:** (sample preparation: 2g of 4 wt% GO in water were dried under vacuum at 60°C overnight)

*Carbon:* 77-87%; *Hydrogen:* 0-1%; *Nitrogen:* 0-1%; *Oxygen:* 13-22%; *Sulfur:* 0%

**Quality Control:** Elemental analysis

**Applications:** Batteries, biomedical, solar cells, supercapacitors, printable graphene electronics, graphene research

**References:**

1. *Nano Letters*, **2010**, 10, 92.
2. *J. Phys. Chem. Lett.*, **2013**, 4, 1347.

<b>06-0318</b>	<b>Graphene powder (1-5 layers thick x 0.5-5 microns wide, surface area 650-750 m<sup>2</sup>/g) (1034343-98-0)</b> C; FW: 12.011; black powdr.	250mg 1g
<b>06-0313</b>	<b>Graphene powder (single layer, surface area 400-1000 m<sup>2</sup>/g) (1034343-98-0)</b> C; FW: 12.011; black powdr.	50mg
<b>06-2510</b>	<b>Monolayer Graphene on Cu (10 mm x 10 mm) (1034343-98-0)</b> C; FW: 12.011; wafer	4pcs

### Physical Properties:

*Growth Method:* Chemical Vapor Deposition (CVD synthesis); *Appearance:* Transparent; *Transparency:* >97%; *Coverage:* 98%; *Layers:* 1; *Thickness (theoretical):* 0.345 nm; *FET Electron Mobility on Al<sub>2</sub>O<sub>3</sub>:* 2000 cm<sup>2</sup>/Vs; *FET Electron Mobility on SiO<sub>2</sub>:* 4000 cm<sup>2</sup>/Vs; *Sheet Resistance on SiO<sub>2</sub>/Si:* 410-490 Ω/sq (1 cm x 1 cm); *Grain size:* Up to 10 μm

### Substrate Cu foil:

*Thickness:* 18 μm

Pretreated for easier bottom layer removal: Monolayer graphene on the back side of Copper is partially removed, but not completely, so an additional treatment like RIE is needed before transfer to eliminate the bottom layer totally

**Applications:** Flexible batteries, electronics, aerospace, MEMS and NEMS, Microactuators, Conductive coatings

**Quality Control:** Raman Spectroscopy and Optical Microscopy

**References:**

1. *J. Electrochem. Soc.*, **2012**, 159, A752.
2. *J. Mater. Chem. A.*, **2013**, 1, 3177.

<b>06-2518</b>	<b>Monolayer Graphene on Cu (60 mm x 40 mm) (1034343-98-0)</b> C; FW: 12.011; wafer	1pc
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### Physical Properties:

*Growth Method:* Chemical Vapor Deposition (CVD synthesis); *Appearance:* Transparent; *Transparency:* >97%; *Coverage:* 95%; *Layers:* 1; *Thickness (theoretical):* 0.345 nm; *FET Electron Mobility on Al<sub>2</sub>O<sub>3</sub>:* 2000 cm<sup>2</sup>/Vs; *FET Electron Mobility on SiO<sub>2</sub>:* 4000 cm<sup>2</sup>/Vs; *Sheet Resistance on SiO<sub>2</sub>/Si:* 410-490 Ω/sq (1 cm x 1 cm); *Grain size:* Up to 10 μm

### Substrate Cu foil:

*Thickness:* 18 μm

Pretreated for easier bottom layer removal: Monolayer graphene on the back side of Copper is partially removed, but not completely, so an additional treatment like RIE is needed before transfer to eliminate the bottom layer totally

**Applications:** Flexible batteries, electronics, aerospace, MEMS and NEMS, Microactuators, Conductive coatings

**Quality control:** Raman Spectroscopy and Optical Microscopy

**References:**

1. *J. Electrochem. Soc.*, **2012**, 159, A752.
2. *J. Mater. Chem. A.*, **2013**, 1, 3177.

# NANOMATERIALS - CARBON (Elemental Forms)

## Carbon, Graphene

06-2523	<b>Monolayer Graphene on Cu with PMMA coating (60mm x 40mm)</b> (1034343-98-0) C; FW: 12.011; wafer	1pc
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### Physical Properties:

*Growth Method:* Chemical Vapor Deposition (CVD synthesis); *Appearance:* Transparent; *Transparency:* >97%; *Coverage:* 95%; *Layers:* 1; *Thickness (theoretical):* 0.345 nm; *FET Electron Mobility on Al<sub>2</sub>O<sub>3</sub>:* 2000 cm<sup>2</sup>/Vs; *FET Electron Mobility on SiO<sub>2</sub>:* 4000 cm<sup>2</sup>/Vs; *Sheet Resistance on SiO<sub>2</sub>/Si:* 410-490 Ω/sq (1 cm x 1 cm); *Grain size:* Up to 10 μm

### Substrate Cu foil:

*Thickness:* 18 μm

Pretreated for easier bottom layer removal: Monolayer graphene on the back side of Copper is partially removed, but not completely, so an additional treatment like RIE is needed before transfer to eliminate the bottom layer totally

**Applications:** Flexible batteries, electronics, aerospace, MEMS and NEMS, Microactuators, Conductive coatings

**Quality control:** Raman Spectroscopy and Optical Microscopy

### References:

1. *J. Electrochem. Soc.*, **2012**, 159, A752.
2. *J. Mater. Chem. A.*, **2013**, 1, 3177.

06-2534	<b>Monolayer Graphene on SiO<sub>2</sub>/Si (10mm x 10mm)</b> (1034343-98-0) C; wafer	4pc
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### Physical Properties:

*Growth Method:* Chemical Vapor Deposition (CVD synthesis); *Appearance:* Transparent; *Transparency:* >97%; *Coverage:* 95%; *Layers:* 1; *Thickness (theoretical):* 0.345 nm; *FET Electron Mobility on Al<sub>2</sub>O<sub>3</sub>:* 2000 cm<sup>2</sup>/Vs; *FET Electron Mobility on SiO<sub>2</sub>:* 4000 cm<sup>2</sup>/Vs; *Sheet Resistance on SiO<sub>2</sub>/Si:* 410-490 Ω/sq (1 cm x 1 cm); *Grain size:* Up to 10 μm

### Substrate Cu foil:


*Dry Oxide Thickness:* 285-315 nm; *Type/Dopant:* P/Bor; *Orientation:* <100>; *Resistivity:* <0.005 Ohm-cm; *Thickness:* 505-545 μm; *Front surface:* single side polished; *Back surface:* etched; *Particles:* <10@0.3 μm


**Applications:** Flexible batteries, electronics, aerospace, MEMS and NEMS, Microactuators, Conductive coatings


**Quality control:** Raman Spectroscopy and Optical Microscopy


### References:

1. *J. Electrochem. Soc.*, **2012**, 159, A752
2. *J. Mater. Chem. A.*, **2013**, 1, 3177

06-0365	<b>Monolayer High Strength Metallurgical Graphene, HSMG®, on GLASS (10x10mm)</b> (1034343-98-0)  C; FW: 12.011; Colorless solid Note: HSMG® Sold under license for research purposes only. U.S. Patent no. 9,284,640 B2.	1pc
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06-0345	<b>Monolayer High Strength Metallurgical Graphene, HSMG®, on PMMA (10x10 mm)</b> (1034343-98-0)  C; FW: 12.011; Colorless solid Note: HSMG® Sold under license for research purposes only. U.S. Patent no. 9,284,640 B2.	1pc
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06-0355	<b>Monolayer High Strength Metallurgical Graphene, HSMG®, on PMMA (25x25mm)</b> (1034343-98-0)  C; FW: 12.011; Colorless solid Note: HSMG® Sold under license for research purposes only. U.S. Patent no. 9,284,640 B2.	1pc
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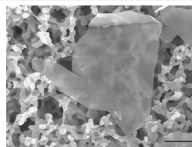
06-0360	<b>Monolayer High Strength Metallurgical Graphene, HSMG®, on PMMA (50x50mm)</b> (1034343-98-0)  C; FW: 12.011; Colorless solid Note: HSMG® Sold under license for research purposes only. U.S. Patent no. 9,284,640 B2.	1pc
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## NANOMATERIALS - CARBON (Elemental Forms)

### Graphene Nanoplatelets

06-0222	<b>Graphene nanoplatelets, (2-10nm thick x ~5 microns wide) (1034343-98-0)</b> C; black solid	25g 5g
06-0210	<b>Graphene nanoplatelets (6-8 nm thick x 5 microns wide) (1034343-98-0)</b> C; black platelet  Note: Graphene nanoplatelets are unique nanoparticles consisting of short stacks of graphene sheets having a platelet shape. They have an average thickness of approximately 6 - 8 nanometers and a typical surface area of 120 to 150 m <sup>2</sup> /g. The unique size and platelet morphology of the graphene nanoplatelets makes these particles especially effective at providing barrier properties and improving mechanical properties, while their pure graphitic composition makes them excellent electrical and thermal conductors.	25g 100g
Technical Note: 1. For detailed note visit <a href="http://www.strem.com">www.strem.com</a> .		
06-0215	<b>Graphene nanoplatelets (6-8 nm thick x 15 microns wide) (1034343-98-0)</b> C; black platelet	25g 100g
Technical Note: 1. See 06-0210 (page 30)		
06-0220	<b>Graphene nanoplatelets (6-8 nm thick x 25 microns wide) (1034343-98-0)</b> C; black platelet	25g 100g
Technical Note: 1. See 06-0210 (page 30)		
06-0225	<b>Graphene nanoplatelets aggregates (sub-micron particles, surface area 300m<sup>2</sup>/g) (1034343-98-0)</b> black platelet  Note: Graphene nanoplatelet aggregates are unique nanoparticles consisting of short stacks of graphene sheets having a platelet shape. They typically consist of aggregates of sub-micron platelets that have a particle diameter of less than 2 microns and a typical particle thickness of a few nanometers, depending on the surface area.  The unique size and platelet morphology of the graphene nanoplatelets makes these particles especially effective at providing barrier properties and improving mechanical properties, while their pure graphitic composition makes them excellent electrical and thermal conductors.	25g 100g
Technical Note: 1. For detailed note visit <a href="http://www.strem.com">www.strem.com</a> .		
06-0230	<b>Graphene nanoplatelets aggregates (sub-micron particles, surface area 500m<sup>2</sup>/g) (1034343-98-0)</b> black platelet	25g 100g
Technical Note: 1. See 06-0225 (page 30)		
06-0235	<b>Graphene nanoplatelets aggregates (sub-micron particles, surface area 750m<sup>2</sup>/g) (1034343-98-0)</b> black platelet	25g 100g
Technical Note: 1. See 06-0225 (page 30)		



# NANOMATERIALS - CARBON (Elemental Forms)

## Graphene Quantum Dots (1034343-98-0)

light sensitive, (store cold)

Note: Particle diameter: <5 nm. Sold in collaboration with Dotz Nano Ltd. for research purposes only.

Suggested use within 6 months of purchase. Do not freeze. Store in DARK.

**06-0330 Graphene Quantum Dots (GQDs), Aqua-Green Luminescent**

100mg

(1034343-98-0)

C; dark red-brown powdr.

### Suggested Applications:

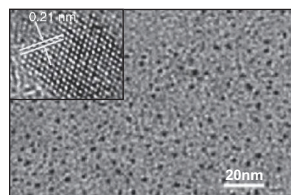
Graphene quantum dots (GQDs), sheets of few-layered graphene and lateral dimensions smaller than 100nm possess strong quantum confinement and edge effects. Thus, they possess unique physical properties such as strong photoluminescence, which can be tailored for specific applications by controlling their size, shape, defects and functionality.

In contrast to classic QDs, such as metal or silicon quantum dots, GQDs are biocompatible, photostable and inherit superior thermal, electrical and mechanical properties from the graphene. These features can greatly contribute to various state-of-the-art applications: optical brighteners, taggants for security applications<sup>1</sup>, bioimaging markers<sup>2</sup>, fluorescent polymers<sup>3</sup>, antibacterial<sup>4</sup>, antibiofouling<sup>5</sup>, and disinfection systems<sup>6</sup>, heavy metals<sup>7</sup>, humidity and pressure<sup>8</sup> sensors, batteries<sup>9</sup>, flash memory devices<sup>10</sup>, photovoltaic devices<sup>11</sup> and light-emitting diodes<sup>12</sup>.

Item #	Photoluminescence			
	QY* *	$\lambda_{\max}$ *	Max emission	FWHM *
<b>06-0330 / 06-0332</b>	>17%	485 nm	525 nm	70 nm
<b>06-0334 / 06-0336</b>	>65%	350 nm	445 nm	65 nm
<b>06-0340</b>	>25%	420 nm	490 nm	80 nm
<b>Abbreviations</b>				
	QY*	Quantum Yield		
	$\lambda_{\max}$	Maximum excitation wavelength		
	FWHM	Full width at half maximum		

### References:

1. <http://onlinelibrary.wiley.com/doi/10.1002/anie.201206791/abstract>
2. <http://onlinelibrary.wiley.com/doi/10.1002/ppsc.201400219/abstract>
3. <http://pubs.acs.org/doi/abs/10.1021/acsami.5b06057>
4. <http://pubs.acs.org/doi/abs/10.1021/acsami.6b01765>
5. <http://www.nature.com/articles/srep20142>
6. <http://pubs.acs.org/doi/abs/10.1021/nn501640q>
7. <http://www.sciencedirect.com/science/article/pii/S0013468615000468>
8. <http://pubs.acs.org/doi/abs/10.1021/nl4003443>
9. <http://pubs.acs.org/doi/abs/10.1021/nl504038s>
10. <http://iopscience.iop.org/article/10.1088/0957-4484/25/25/255203/meta>
11. <http://onlinelibrary.wiley.com/doi/10.1002/anie.200906291/abstract>
12. <http://link.springer.com/article/10.1007/s10853-012-7016-8>



**06-0332 Graphene Quantum Dots (GQDs) in water, Aqua-Green Luminescent (1034343-98-0)**

100ml

C; cloudy orange liq.

Note: Concentration: 1 mg/ml.

### Technical Note:

1. See 06-0330 (page 31)

**06-0334 Graphene Quantum Dots (GQDs), Blue Luminescent (1034343-98-0)**

100mg

C; dark brown powdr.

### Technical Note:

1. See 06-0330 (page 31)

**06-0336 Graphene Quantum Dots (GQDs) in water, Blue Luminescent (1034343-98-0)**

100ml

C; cloudy colorless liq.

Note: Concentration: 1 mg/ml.

### Technical Note:

1. See 06-0330 (page 31)

**06-0340 Graphene Quantum Dots (GQDs) in water, Cyan Luminescent (1034343-98-0)**

100ml

C; cloudy brown liq.

Note: Concentration: 1 mg/ml.

### Technical Note:

1. See 06-0330 (page 31)

## NANOMATERIALS - CARBON (Elemental Forms)

### Graphene Quantum Dots (1034343-98-0)

light sensitive, (store cold)

Note: Particle diameter: <5 nm. Sold in collaboration with Dotz Nano Ltd. for research purposes only.

Suggested use within 6 months of purchase. Do not freeze. Store in DARK.

#### 96-7410 Graphene Quantum Dots (GQDs) Master Kit (1034343-98-0)

See page 61

#### 96-7425 Graphene Quantum Dots (GQDs) Mini Kit (Powders) (1034343-98-0)

See page 62

#### 96-7420 Graphene Quantum Dots in water (GQDs) Mini Kit (Liquids) (1034343-98-0)

See page 62

### Carbon Nanotubes

**06-0440 Carbon nanotube array, multi-walled, on quartz (diameter= 100nm, length=30 microns ) (308068-56-6)**  
black microfibers;  
(diameter=100nm, length=30microns)



1pc

Technical Note:

1. Arrays grown on 10x10x1mm quartz substrate using a single source CVD process that yields vertically aligned MWNTs (< 1% catalyst impurity). Arrays are 30µm tall (± 3µm) and are composed of MWNTs 100nm in diameter (± 10nm). Arrays up to 150µm can be provided on request.

**06-0470 Carbon nanotubes, multi-walled (diameter = ~140nm, length = ~7 microns)**

(>90% nanotubes) (308068-56-6)

black pwdr.

1g

5g

Technical Note:

1. Produced by chemical vapor deposition. Typical metal content is <0.1%.

**06-0475 Carbon nanotubes, multi-walled (diameter = ~20-25nm, length = ~1-5 microns)**

(85% nanotubes) (308068-56-6)

black pwdr.

250mg

1g

Technical Note:

1. Produced by chemical vapor deposition. Typical metal content is 4-5 wt %.

**06-0720 Carbon nanotubes, multi-walled, arc-produced (diameter = 2-50nm, length =**

**>2 microns) (55-65wt% nanotubes) (308068-56-6)**

black pwdr.

250mg

1g

Technical Note:

1. Arc-produced, multi-walled carbon nanotubes contain 55-65 wt% nanotubes and 35-45wt% graphite nanoparticles. The tubes have a diameter distribution of 2-50 nm, and a typical length of >2 microns (straight tubes). The chemical composition is 100% carbon, with no metal impurities. Because the nanotubes are grown at very high temperatures (3000-4000°C), the product contain far less defects than nanotubes produced by other methods. The nanotubes are stable in air up to 700°C.

**06-0504 Carbon nanotubes, multi-walled, as produced cathode deposit (308068-56-6)**  
pieces

1g

5g

**06-0505 Carbon nanotubes, multi-walled, core material (308068-56-6)**

pieces (20-40% nanotubes)

1g

5g

**06-0506 Carbon nanotubes, multi-walled, ground core material (308068-56-6)**

-270 mesh pwdr. (20-40%nanotubes)

250mg

1g

5g

**06-0508 Carbon nanotubes, single-walled/double-walled, 90% (308068-56-6)**

pwdr.

250mg

1g

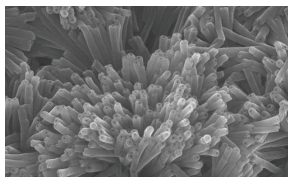
Technical Note:

1. This product is nanotubes, single-walled/double-walled, 90%. The tubes are 1-2nm in diameter with lengths of 5-30 microns. Ash is <1.5wt%.

## NANOMATERIALS - CARBON (Elemental Forms)

### Carbon Nanotubes

- 06-1060** Polydiacetylene nanotube (PDNT-12-8-22Br)  
blue solid  
Note: Sold in collaboration with LIG Sciences for research purposes only. US Patent No. 7,666,911.



100mg  
500mg

#### Technical Note:

1. Polydiacetylene Nanotubes (PDNT) are self-assembled diacetylene nanotubes comprised of cross-linking of conjugated double and triple bonds. They are produced using a proprietary molecular self-assembly process that results in remarkably uniform, pure, air-stable blue nanotubes (ID 34nm, OD 98nm and length 1-3 $\mu$ m). PDNT nanotubes exhibit thermochromism either on different substrates or in solvents. This unique thermo- and mechano-chromic behavior has been demonstrated to be completely reversible for hundreds of cycles.

## NANOMATERIALS - CERIUM (Compounds)

- 58-0860** Cerium(IV) oxide [contains some Ce(III)] in water at pH = 3.5  $\pm$  0.75 25g  
HAZ (CEO-W320) (1306-38-3) 100g  
CeO<sub>2</sub>; FW: 172.12; red-brown mixture; d. 1.23 500g  
(store cold)  
Note: Store at 5 to 25°C. Do not freeze. Suggested use within 12 months of receipt.  
Sold in collaboration with Cerion for research purposes only.

% Solids: 20  $\pm$  0.5%

pH: 3.5  $\pm$  0.75

Useable pH Range: 2-5

Mean Number Weighted Particle Diameter: 3.0 nm (by Dynamic Light Scattering)

Polydispersity Index: <0.25

Chemical Composition (particles): >99.5% CeO<sub>2</sub>

- 58-1400** Cerium(IV) oxide nanopowder (1306-38-3) 25g  
CeO<sub>2</sub>; FW: 172.12; yellow powdr. 100g

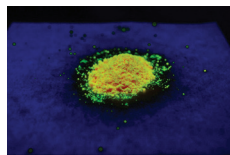
## NANOMATERIALS - COPPER (Elemental Forms)

- 29-0092** Copper nanoparticles, pure, (<20nm) in acetone at 100mg/L (surfactant and 25ml  
HAZ reactant-free) (7440-50-8) 100ml  
brown liq.  
Note: Made to order. Manufactured by laser ablation. Store at room temperature (up to 25°C). Do not freeze. Shelf life 12 months. Sold in collaboration with Particular® for research purposes only.

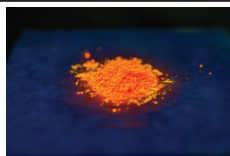
## NANOMATERIALS - COPPER (Compounds)

- Copper Indium Disulfide/Zinc Sulfide Quantum Dots (927198-36-5)** 50mg  
Note: Particle size: 5-10 nm. Recommend long-term storage in dark, under inert atmosphere. Sold 250mg  
under a distribution agreement with UbiQD, Inc. for research purposes only. US Patent No. US9748422.  
Suggested use within 12 months of receipt.

- 29-8500** Copper Indium Disulfide/Zinc Sulfide Quantum Dots, 50mg  
**NEW** Peak Emission 550nm  $\pm$  10nm, QY > 75% (927198-36-5) 250mg  
CuInS<sub>2</sub>ZnS; yellow powdr.  
Note: FWHM 250nm  $\pm$  20nm.



- 29-8510** Copper Indium Disulfide/Zinc Sulfide Quantum Dots, 50mg  
**NEW** Peak Emission 590nm  $\pm$  10nm, QY > 75% (927198-36-5) 250mg  
CuInS<sub>2</sub>ZnS; orange powdr.  
Note: FWHM 120nm  $\pm$  20nm.



## NANOMATERIALS - COPPER (Compounds)

### Copper Indium Disulfide/Zinc Sulfide Quantum Dots (927198-36-5)

50mg  
250mg

Note: Particle size: 5-10 nm. Recommend long-term storage in dark, under inert atmosphere. Sold under a distribution agreement with UbiQD, Inc. for research purposes only. US Patent No. US9748422.

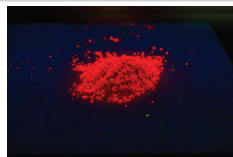
Suggested use within 12 months of receipt.

29-8520

NEW

**Copper Indium Disulfide/Zinc Sulfide Quantum Dots,**  
**Peak Emission 630nm  $\pm$  10nm, QY > 75% (927198-36-5)**  
CuInS<sub>2</sub>ZnS; red powdr.

Note: FWHM 125nm  $\pm$  20nm.

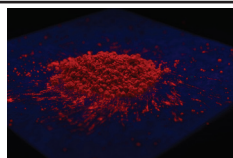


29-8530

NEW

**Copper Indium Disulfide/Zinc Sulfide Quantum Dots,**  
**Peak Emission 680nm  $\pm$  10nm, QY > 75% (927198-36-5)**  
CuInS<sub>2</sub>ZnS; brown powdr.

Note: FWHM 130nm  $\pm$  20nm.



29-8540

NEW

**Copper Indium Disulfide/Zinc Sulfide Quantum Dots,**  
**Peak Emission 800nm  $\pm$  10nm, QY > 75% (927198-36-5)**  
CuInS<sub>2</sub>ZnS; black powdr.

Note: FWHM 180nm  $\pm$  20nm.



29-8550

NEW

**Copper Indium Disulfide/Zinc Sulfide Quantum Dots,**  
**Peak Emission 950nm  $\pm$  10nm, QY > 75% (927198-36-5)**  
CuInS<sub>2</sub>ZnS; black powdr.

Note: FWHM 250nm  $\pm$  20nm.



## NANOMATERIALS - GOLD (Elemental Forms)

### Gold AUROLite™ Heterogeneous Catalysts

(store cold)

10g  
50g

Note: Sold in collaboration with Project AuTEK for research purposes. Reverse engineering and product modification prohibited. Only open before use, store cold in dark. See web for more details.

79-0160

**Gold 1% on aluminum oxide extrudates (AUROLite™ Au/Al<sub>2</sub>O<sub>3</sub>) (7440-57-5)**  
dark purple extrudates ~1.2mm dia. x 5mm (avg)

Technical Note:

1. Useful product for the catalytic oxidation of a variety of substrates including carbon monoxide, aldehydes, alkenes, methane and ethanol. Average gold crystallite size is ~2-3nm.

**Analysis:** Au 1 wt%  $\pm$  0.1%; Al<sub>2</sub>O<sub>3</sub> 98 wt%; Na+, Cl- <1500ppm

**Bulk density:** 0.6–0.8 g/ml

References:

1. *J. Catal.*, **2007**, 252, 119
2. *J. Catal.*, **2008**, 260, 86
3. *Green Chem.*, **2008**, 10, 168
4. *Gold Bulletin*, **2008**, 41, 296
5. *Appl. Catal. B.*, **2013**, 132, 195
6. *Chem. Rev.*, **2012**, 112, 4469

## NANOMATERIALS - GOLD (Elemental Forms)

### Gold AUROLite™ Heterogeneous Catalysts

(store cold)

10g

50g

Note: Sold in collaboration with Project AuTEK for research purposes. Reverse engineering and product modification prohibited. Only open before use, store cold in dark. See web for more details.

#### 79-0165 Gold 1% on titanium dioxide extrudates (AUROLite™ Au/TiO<sub>2</sub>) (7440-57-5)

dark purple/gray extrudates 1.5mm dia. x 5mm (avg)

Technical Note:

1. Useful product for the catalytic oxidation of a variety of substrates including carbon monoxide, aldehydes, alkenes, methane and ethanol. Average gold crystallite size is ~2-3nm.

**Analysis:** Au 1 wt% ± 0.1%; TiO<sub>2</sub> 98 wt%; Na+, Cl- <1500ppm

**Bulk density:** 0.85–0.95 g/ml

References:

1. *J. Catal.*, **2007**, 252, 119
2. *J. Catal.*, **2008**, 260, 86
3. *Green Chem.*, **2008**, 10, 168
4. *Gold Bulletin*, **2008**, 41, 296
5. *Appl. Catal. B.*, **2013**, 132, 195
6. *Chem. Rev.*, **2012**, 112, 4469

#### 79-0170 Gold 1% on zinc oxide granulate (AUROLite™ Au/ZnO) (7440-57-5)

dark purple granulate 1-2mm dia.

Note: PCT WO2005115612.

Technical Note:

1. Useful product for the catalytic oxidation of a variety of substrates including carbon monoxide, aldehydes, alkenes, methane and ethanol. Average gold crystallite size is ~2-3nm.

**Analysis:** Au 1 wt% ± 0.1%; ZnO 88 wt% (contains Al<sub>2</sub>O<sub>3</sub>); Na+, Cl- <1500ppm

**Bulk density:** 1-1.2 g/ml

References:

1. *J. Catal.*, **2007**, 252, 119
2. *J. Catal.*, **2008**, 260, 86
3. *Green Chem.*, **2008**, 10, 168
4. *Gold Bulletin*, **2008**, 41, 296
5. *Appl. Catal. B.*, **2013**, 132, 195
6. *Chem. Rev.*, **2012**, 112, 4469

### Gold - Colloid

250mg

Note: Made to order. Long term shelf life not established.

1g

#### 79-0080 Gold/tetra-n-octylammonium chloride colloid (7440-57-5)

Au/(C<sub>8</sub>H<sub>17</sub>)<sub>4</sub>NCl; 2.6 nm ± 1.1 nm; brown-orange solid

(store cold)

Technical Note:

1. Soluble in toluene. Precursor for CO-oxidation catalysts.

### Gold Nanochain

25ml

#### 79-0134 Gold Nanochain [AuNP-Chain: 1-2 μm (Gum Arabic)] (7440-57-5)

maroon-red liq.

(store cold)

**Properties:** Water soluble, stable at pH 7.0; **Chain length:** 1-2 μm; **Shape:** Chain; **UV-Vis (nm):** 760 nm;

**Stability:** Stable for 90 days; Size: 7 ± 3nm

Ordering Specifications: Minimum 2 weeks required to process the order.

Supplied in aqueous solutions. Contains gum arabic stabilizer. Suitable for spin coating, self-assembly and monolayer formation. Sensor design, nanoelectronics and MEMS applications.



# NANOMATERIALS - GOLD (Elemental Forms)

## Gold Nanoparticles - Solid and Functionalized

<b>79-0235</b>	<b>Gold nanoparticles powder, 6nm, organic solvent-dispersible (7440-57-5)</b>	5mg 25mg
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black pwdr.

Note: 79-0235 is an organic soluble solid. The surface ligand is dodecanethiol. The hydrodynamic size of the nanoparticles is about 8-10nm larger than their inorganic core size measured by TEM.

<b>79-0238</b>	<b>Gold nanoparticles with amine surface functional group, 6nm, in water (7440-57-5)</b>	5mg 25mg
----------------	--	-------------

dark red liq.

Note: 79-0238 is a group of water-soluble gold nanoparticles with amphiphilic polymer and PEG coating. The reactive group is an amine.

### Technical Notes:

1. Zeta potential of 79-0238 is from -10mV to 0 mV.
2. Total thickness of organic layers is ~6 nm.
3. The organic layers consist of a monolayer of dodecanethiol, a monolayer of amphiphilic polymer and a monolayer of PEG.
4. The hydrodynamic size of the nanocrystals is about 12-14 nm larger than their inorganic core size as measured by TEM.
5. 79-0238 is very stable in buffer solutions in the pH range of 4-10 and can survive the autoclaving (121°C for 30 mins.).
6. The long term stability is not as good as that of 79-0240.
7. Check expiration date before conjugating.
8. 79-0238 can be conjugated to carbonyl or thiol-containing molecules.

<b>79-0240</b>	<b>Gold nanoparticles with carboxylic acid surface functional group, 6nm, in water (7440-57-5)</b>	10mg 50mg
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dark red liq.

Note: 79-0240 is a group of water-soluble gold nanoparticles with amphiphilic polymer. The reactive group is a carboxylic acid.

### Technical Notes:

1. Zeta potential is from -30mV to -50 mV.
2. Total thickness of organic layers is ~4 nm.
3. The organic layers consist of a monolayer of dodecanethiol and a monolayer of amphiphilic polymer.
4. The hydrodynamic size of the nanoparticles is about 8-10 nm larger than their inorganic core size as measured by TEM.
5. 79-0240 is very stable in buffer solutions in the pH range of 4-10 and can survive the autoclaving (121°C for 30 min.).
6. 79-0240 can be conjugated to protein, peptide, and other amine-containing molecules.

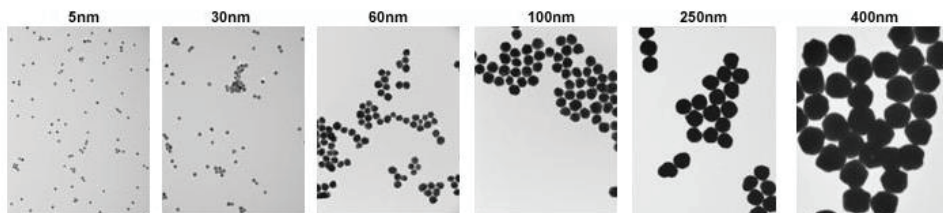
## NANOMATERIALS - GOLD (Elemental Forms)

### Gold Nanoparticles - Reactant Free

>99% free of residual reactant in 0.1mM phosphate buffer.

Store away from direct sunlight at 4°C. Do not freeze. Shelf life 6 months.

*light sensitive; (store cold)*



**Gold Nanoparticles (1 OD, stabilized suspension in phosphate-buffered saline) reactant free**  
(7440-57-5)

25ml  
100ml

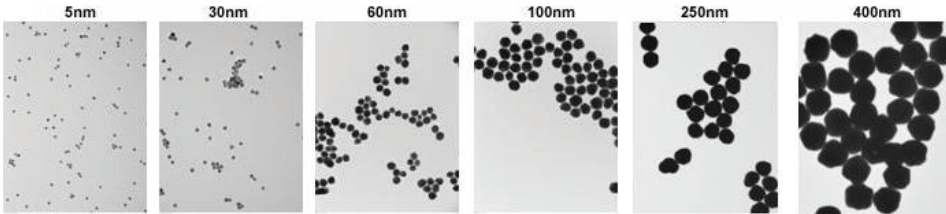
Catalog #	Diameter	Color and form	Absorption max.
79-0180*	5nm	red liq.	515-520nm
79-0184*	10nm	red liq.	520nm
79-0186*	15nm	red liq.	520nm
79-0188*	20nm	red liq.	524nm
79-0190*	30nm	red liq.	526nm
79-0192*	40nm	red liq.	530nm
79-0194	50nm	red liq.	535nm
79-0196	60nm	pink to bright-red liq.	539nm
79-0198	80nm	pink to bright-red liq.	
79-0202	80nm	pink to bright-red liq.	
79-0204	90nm	pink to bright-red liq.	
79-0206	100nm	pink to bright-red liq.	
79-0208	150nm	pink to bright-red liq.	
79-0220	200nm	pink to bright-red liq.	
79-0222	250nm	pink to bright-red liq.	
79-0224	300nm	pink to bright-red liq.	
79-0228	400nm	pink to bright-red liq.	

\*Gold Nanoparticles Kit, Reactant Free component. See page 60

**96-1545 Gold Nanoparticles Kit, Reactant-Free (5nm-40nm diameter, OD 1, suspension in phosphate-buffered saline, 515-530nm abs. max.) (7440-57-5)**  
See page 60

NANOMATERIALS - GOLD (Elemental Forms)

**Gold Nanoparticles - Stabilizing Surfactant (1 OD, supplied in 0.1mM stabilizing surfactant)**  
Store away from direct sunlight at 4°C. Do not freeze. Shelf life 6 months.  
*light sensitive, (store cold)*



Gold Nanoparticles (1 OD, supplied in 0.1mM stabilizing surfactant) (7440-57-5)

25ml  
100ml

Catalog #	Diameter	Color and form	Absorption max.
79-0182*	5nm	red liq.	515-520nm
79-0210*	10nm	red liq.	515-520nm
79-0212*	15nm	red liq.	520nm
79-0214*	20nm	red liq.	524nm
79-0216*	30nm	red liq.	526nm
79-0218*	40nm	red liq.	530nm
79-0260	50nm	pink to bright-red liq.	535nm
79-0262	60nm	pink to bright-red liq.	540nm
79-0264	70nm	pink to bright-red liq.	548nm
79-0266	80nm	pink to bright-red liq.	553nm
79-0268	90nm	pink to bright-red liq.	564nm
79-0270	100nm	pink to bright-red liq.	572nm
79-0272	150nm	pink to bright-red liq.	
79-0274	200nm	pink to bright-red liq.	
79-0276	250nm	pink to bright-red liq.	
79-0278	300nm	pink to bright-red liq.	
79-0280	400nm	pink to bright-red liq.	

\*Gold Nanoparticles Kit, stabilized suspension citrate buffer component. See page 59

96-1547	Gold Nanoparticles Kit (5nm-40nm diameter, OD 1, stabilized suspension citrate buffer) (7440-57-5) See page 59
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## NANOMATERIALS - GOLD (Elemental Forms)

### Gold Nanoparticles - Spherical

Concentration: 0.03mg/ml ( $\pm 10\%$ )

Storage Conditions: (*store cold*), store at  $\sim 4^{\circ}\text{C}$  (do not freeze)

Shelf Life: 6 months

5ml

25ml

**79-6040 Spherical Gold Nanoparticles (30 nm) (7440-57-5)**  
orange pink liq.  
Note: Spherical Gold Nanoparticles Kit component.

**79-6045 Spherical Gold Nanoparticles (50 nm) (7440-57-5)**  
pink liq.  
Note: Spherical Gold Nanoparticles Kit component.

**79-6050 Spherical Gold Nanoparticles (70 nm) (7440-57-5)**  
pink liq.  
Note: Spherical Gold Nanoparticles Kit component.

**79-6055 Spherical Gold Nanoparticles (90 nm) (7440-57-5)**  
violet liq.  
Note: Spherical Gold Nanoparticles Kit component.

**96-1540 Gold Nanospheres Kit (30-90 nm) (7440-57-5)**  
See page 61

### Gold Nanoparticles - Sugar Coated

(*store cold*)

5ml

**79-0124 Sugar Coated Gold Nanoparticles [AuNP: 1-2 nm (Lactose)] (7440-57-5)**  
maroon-red liq.

**Properties:** Water soluble; **Size:** 22-38, 4-16, 6-10 or 1-2 nm; **Shape:** Sphere; **UV-Vis (nm):** 535, 535, 540 or 540 nm;

**Stability:** After generation from kit components - Stable for 1 day.

Supplied as kit. Suitable for in vitro use and sensor design applications.

**79-0122 Sugar Coated Gold Nanoparticles [AuNP: 6-10 nm (Maltose)] (7440-57-5)**  
maroon-red liq.

**Properties:** Water soluble; **Size:** 22-38, 4-16, 6-10 or 1-2 nm; **Shape:** Sphere; **UV-Vis (nm):** 535, 535, 540 or 540 nm;

**Stability:** After generation from kit components - Stable for 1 day.

Supplied as kit. Suitable for in vitro use and sensor design applications.

### Gold Nanoparticles - Surfactant and Reactant-Free (Pure), Manufactured via Laser Ablation

Note: Made to order. Manufactured by laser ablation. Store at room temperature (up to  $25^{\circ}\text{C}$ ).

Do not freeze. Shelf life 12 months. Sold in collaboration with Particular® for research purposes only.

25ml

100ml

**79-0412 Gold nanoparticles, pure, (<20nm) in acetone at 100mg/L (surfactant and reactant-free)**  
HAZ (7440-57-5)  
red liq.

**79-0416 Gold nanoparticles, pure, (<20nm) in isopropanol at 100mg/L (surfactant and reactant-free)**  
HAZ (7440-57-5)  
red liq.

**79-0410 Gold nanoparticles, pure, (<20nm) in water at 100mg/L (surfactant and reactant-free, OD>1, stabilized with < 0.01 mmol/l of citrate) (7440-57-5)**  
red liq.

**79-0418 Gold nanoparticles, pure, (<20nm) in water at 500mg/L (surfactant and reactant-free, OD>5, stabilized with < 0.01 mmol/l of citrate) (7440-57-5)**  
dark red liq.

## NANOMATERIALS - GOLD (Elemental Forms)

### Gold Nanoparticles - Surfactant and Reactant-Free (Supported), Manufactured via Laser Ablation (7440-57-5), (store cold)

Note: Manufactured by laser ablation. Sold in collaboration with Particular® for research purposes only.

<b>79-0921</b>	<b>Gold nanoparticles, 1% on carbon black (surfactant and reactant-free)</b> (7440-57-5) Au; FW: 196.70; black solid	5g 25g
<b>79-0916</b>	<b>Gold nanoparticles, 1% on Titania (anatase) (surfactant and reactant-free)</b> (7440-57-5) Au; FW: 196.70; dark purple pwr.	5g 25g
<b>79-0905</b>	<b>Gold nanoparticles, 1% on Titania (anatase/rutile) (surfactant and reactant-free)</b> (7440-57-5) Au; FW: 196.70; purple solid	5g 25g
<b>79-0926</b>	<b>Gold nanoparticles, 5% on carbon black (surfactant and reactant-free)</b> (7440-57-5) Au; FW: 196.70; black solid	5g 25g
<b>79-0935</b>	<b>Gold nanoparticles, 10% on Titania (anatase) (surfactant and reactant-free)</b> (7440-57-5) Au; FW: 196.70; purple solid	1g 5g
<b>79-0930</b>	<b>Gold nanoparticles, 10% on Titania (anatase/rutile) (surfactant and reactant-free)</b> (7440-57-5) Au; FW: 196.70; dark purple solid	1g 5g

### Gold Nanoparticles - Water Soluble

(store cold) 25ml  
100ml

**79-0110**      **Water Soluble Gold Nanoparticles [AuNP: 3nm (Citrate)] (7440-57-5)**  
wine-red liq.

**Properties:** Water soluble; **Size:** 3 nm, 5 nm, 10 or 15 nm; **Shape:** Sphere; **UV-Vis (nm):** 520, 525, 520 or 525 nm;  
**Stability:** Stable for 90 days in aqueous media.

Supplied in aqueous solutions. Contains citrate stabilizer. Suitable for spin coating, self-assembly and monolayer formation.

**79-0112**      **Water Soluble Gold Nanoparticles [AuNP: 5nm (Citrate)] (7440-57-5)**  
wine-red liq.

**Properties:** Water soluble; **Size:** 3 nm, 5 nm, 10 or 15 nm; **Shape:** Sphere; **UV-Vis (nm):** 520, 525, 520 or 525 nm;  
**Stability:** Stable for 90 days in aqueous media.

Supplied in aqueous solutions. Contains citrate stabilizer. Suitable for spin coating, self-assembly and monolayer formation.

**79-0114**      **Water Soluble Gold Nanoparticles [AuNP: 10 nm (Citrate)] (7440-57-5)**  
wine-red liq.

Technical Note:

1. See 79-0110 (page 40)

**79-0116**      **Water soluble Gold Nanoparticles [AuNP: 15 nm (Citrate)] (7440-57-5)**  
wine-red liq.

Technical Note:

1. See 79-0110 (page 40)

**79-0126**      **Water Soluble Gold Nanoparticles [AuNP: 11-20 nm (Gelatin)] (7440-57-5)**  
wine-red liq.

**Properties:** Water soluble; **Size:** 11-20 nm; **Shape:** Sphere; **UV-Vis (nm):** 540 nm; **Stability:** Stable for 90 days in aqueous media. Suitable for spin coating, self-assembly and monolayer formation. Suitable for in vitro use and sensor design applications.

**79-0108**      **Water Soluble Gold Nanoparticles [AuNP: 12-16 nm (Starch)] (7440-57-5)**  
maroon-red liq.

**Properties:** Water soluble, stable at pH 7.0; **Size:** 30-40 nm; **Shape:** Sphere; **UV-Vis (nm):** 535 nm;  
**Stability:** Stable for 30 days in aqueous media.

Supplied in aqueous solutions. Contains starch stabilizer. Suitable for spin coating, self-assembly and monolayer formation.

References:

1. *Appl. Phys. Lett.*, **2006**, *88*, 153114
2. *J. Am. Chem. Soc.*, **2006**, *128*, 11342

# NANOMATERIALS - GOLD (Elemental Forms)

## Gold Nanorods

5ml

**79-0136**     **Gold Nanorods [AuNP-Rod: Aspect Ratio: 3-3.5 (CTAB)] (7440-57-5)**  
maroon-red liq.  
(store cold)

**Properties:** Water soluble; **Aspect Ratio:** 3-3.5; **Shape:** Rod; **UV-Vis (nm):** 680 nm; **Stability:** Stable for 14 days  
Supplied in aqueous solutions. Contains CTAB stabilizer. Ready for biomolecule conjugation. Suitable for in vitro use and sensor design applications.

## Gold Nanorods (Axial Diameter - 25nm) (7440-57-5)

5ml

Storage Conditions: (store cold) Store at 4°C. Do not freeze.     Shelf Life: 6 months

25ml

Technical Note:

Catalog #	79-6000	79-6005	79-6010	79-6015
<b>Concentration</b>	171 ug/ml (±10%)	235 ug/ml (±10%)	150 ug/ml (±10%)	91 ug/ml (±10%)
<b>Axial diameter (nm)</b>	25 (±10%)	25 (±10%)	25 (±10%)	25 (±10%)
<b>Longitudinal Size (nm)</b>	34 (±10%)	47 (±10%)	60 (±10%)	73 (±10%)
<b>Peak Longitudinal Surface Plasmon Resonance Wavelength (nm)</b>	550	600	650	700
<b>Peak Axial Surface Plasmon Resonance Wavelength (nm)</b>	530	530	530	530
<b>Color and Form</b>	red liq.	blue liq.	blue liq.	gray liq.

\*Gold Nanorods Kit (Axial Diameter - 25nm) component. See page 60

**79-6000**     **Gold Nanorods (Axial Diameter - 25 nm) (Wavelength 550 nm) (7440-57-5)**  
**79-6005**     **Gold Nanorods (Axial Diameter - 25 nm) (Wavelength 600 nm) (7440-57-5)**  
**79-6010**     **Gold Nanorods (Axial Diameter - 25 nm) (Wavelength 650 nm) (7440-57-5)**  
**79-6015**     **Gold Nanorods (Axial Diameter - 25 nm) (Wavelength 700 nm) (7440-57-5)**  
**96-1530**     **Gold Nanorods Kit (Axial Diameter - 25 nm, wavelength 550-700 nm) (7440-57-5)**  
 See page 60

## Gold Nanorods (Axial Diameter - 10nm) (7440-57-5)

5ml

Storage Conditions: (store cold) Store at 4°C. Do not freeze.     Shelf Life: 6 months

25ml

Technical Note:

Catalog #	79-6020	79-6025	79-6030	79-6035
<b>Concentration</b>	30 ug/ml (±10%)	34 ug/ml (±10%)	35 ug/ml (±10%)	36 ug/ml (±10%)
<b>Axial diameter (nm)</b>	10 (±10%)	10 (±10%)	10 (±10%)	10 (±10%)
<b>Longitudinal Size (nm)</b>	29 (±10%)	35 (±10%)	38 (±10%)	41 (±10%)
<b>Peak Longitudinal Surface Plasmon Resonance Wavelength (nm)</b>	700	750	780	808
<b>Peak Axial Surface Plasmon Resonance Wavelength (nm)</b>	512	512	512	512
<b>Color and Form</b>	pale red-brown liq.	pale red liq.	pale red solution	pale red liq.

\*Gold Nanorods Kit (Axial Diameter - 10nm) component. See page 60

**79-6020**     **Gold Nanorods (Axial Diameter - 10 nm) (Wavelength 700 nm) (7440-57-5)**  
**79-6025**     **Gold Nanorods (Axial Diameter - 10 nm) (Wavelength 750 nm) (7440-57-5)**  
**79-6030**     **Gold Nanorods (Axial Diameter - 10 nm) (Wavelength 780 nm) (7440-57-5)**  
**79-6035**     **Gold Nanorods (Axial Diameter - 10 nm) (Wavelength 808 nm) (7440-57-5)**  
**96-1535**     **Gold Nanorods Kit (Axial Diameter - 10 nm, wavelength 550-700 nm) (7440-57-5)**  
 See page 60



# NANOMATERIALS - GOLD (Elemental Forms)

## Gold Nanorods, CTAB Free

*light sensitive, (store cold)*

Note: Rods are synthesized without CTAB. Store at 4°C - 8°C. Do not freeze. At storage temperature the product may appear opaque. Follow the procedure for re-dispersing surfactants as described in the technical note. Complete this process before use to dissolve precipitated stabilizer. Sold in Collaboration with SONA Nanotech for research purposes only. Gold Gemini Nanorods Kit component.

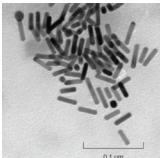
5ml  
25ml

**79-7010**      **Gold Gemini Nanorods, CTAB Free (Wavelength 650 nm) (7440-57-5)**  
**NEW**      Au; violet liq.

Technical Note:

Item #	LPSR Maximum (nm)	Length (nm)	Width (nm)	Aspect Ratio	Color & Form
79-7010	640 - 670	25 - 31	13 - 18	1.7 - 1.9	violet liq.
79-7015	685 - 715	37 - 43	13 - 18	2.4 - 2.8	blue liq.
79-7020	735 - 765	37 - 44	10 - 13	3.4 - 3.7	red-purple liq.
79-7025	785 - 815	40 - 50	10 - 13	3.8 - 4.1	red-orange liq.
79-7030	835 - 865	48 - 55	9 - 12	4.6 - 5.3	maroon-purple liq.

**Concentration:** >30 µg/ml  
**pH:** 5.5 - 7.5  
**Stabilizer:** Amphiphilic Agents  
**Solvent:** Stabilized with amphiphilic agents in conductivity grade water (18.0 MQ cm<sup>-1</sup>)  
**Optical Density:** 1.0 - 1.2  
**Shelf Life:** 12 months



**79-7015**      **Gold Gemini Nanorods, CTAB Free (Wavelength 700 nm) (7440-57-5)**  
**NEW**      Au; blue liq.

Technical Note:

- See 79-7010 (page 42)

**79-7020**      **Gold Gemini Nanorods, CTAB Free (Wavelength 750 nm) (7440-57-5)**  
**NEW**      Au; red-purple liq.

Technical Note:

- See 79-7010 (page 42)

**79-7025**      **Gold Gemini Nanorods, CTAB Free (Wavelength 800 nm) (7440-57-5)**  
**NEW**      Au; red-orange liq.

Technical Note:

- See 79-7010 (page 42)

**79-7030**      **Gold Gemini Nanorods, CTAB Free (Wavelength 850 nm) (7440-57-5)**  
**NEW**      Au; maroon-purple liq.

Technical Note:

- See 79-7010 (page 42)

**96-1549**      **Gold Gemini Nanorods Kit, CTAB Free (Wavelength 650-850 nm)**  
 See page 59

## NANOMATERIALS - GOLD (Elemental Forms)

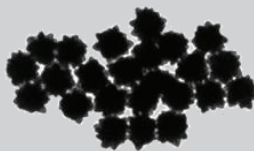
**Gold NanoUrchins (1 OD, 0.1 mM in phosphate-buffered saline) >95.0% reactant free**  
blue liq.

*light sensitive, (store cold)*

Note: Store away from direct sunlight at 4°C. Do not freeze.

Shelf life 6 months.

20ml  
100ml



Technical Note:

Product #	Diameter	Color and form	Absorption max
79-0310	50nm	blue liq.	585nm
79-0313	60nm	blue liq.	585nm
79-0315	70nm	blue liq.	600nm
79-0318	80nm	blue liq.	620nm
79-0320	90nm	blue liq.	630nm
79-0323	100nm	blue liq.	680nm

## NANOMATERIALS - GOLD (Compounds)

**79-2035 Hexachlorododecakis[diphenyl(m-sulfonophenyl)phosphine]pentapentacontagold, dodecasodium salt (water soluble) Schmid Au<sub>55</sub> Cluster (115804-59-6)**  
 $\text{Na}_{12}\{\text{Au}_{55}[\text{P}(\text{C}_6\text{H}_5)_2(\text{C}_6\text{H}_4\text{SO}_3)]_{12}\text{Cl}_6\}$ ; FW: 15417.85; black solid

10mg

## NANOMATERIALS - IRIIDIUM (Compounds)

**Antimony Tin Oxide/Iridium Het-WOC core/shell nanopowder (conductive and acid-stable)**

HAZ; blue powdr.; ATO Composition: 90% SnO<sub>2</sub>, 10% Sb<sub>2</sub>O<sub>3</sub> (w/w)

Note: Sold under license from Catalytic Innovations, LLC for research purposes only.

US Patent Publication No. US20150021194 A1.

Technical Note:

50g  
250g

Product #	Particle Size	BET Surface Area	Resistivity
77-0030	20nm	50 - 60m <sup>2</sup> /g	0.3 - 0.7 Ω·cm
77-0035	50nm	40 - 50m <sup>2</sup> /g	0.05 - 0.08 Ω·cm
77-0040	100nm	5 - 10m <sup>2</sup> /g	0.05 - 0.08 Ω·cm

## NANOMATERIALS - IRON (Compounds)

**Iron Magnetic Fluids**

2ml  
10ml

**26-0032 Iron(II,III) oxide (Magnetite) aqueous magnetic fluid [3.5 vol%, Ms = 15-16 kA/m] (1317-61-9)**

Fe<sub>3</sub>O<sub>4</sub>; black solid (water suspension)

**26-0036 Iron(II,III) oxide (Magnetite) aqueous magnetic fluid [7.0 vol%, Ms = 30-31 kA/m] (1317-61-9)**

Fe<sub>3</sub>O<sub>4</sub>; black solid (water suspension)

**26-0022 Iron(II,III) oxide (Magnetite) magnetic fluid in kerosene with oleic acid**  
HAZ [7-9 vol%, Ms = 35-45 kA/m] (1317-61-9)

black, viscous liq.

**26-0024 Iron(II,III) oxide (Magnetite) magnetic fluid in kerosene with oleic acid**  
HAZ [15-18 vol%, Ms = 50-70 kA/m] (1317-61-9)

black, viscous liq.

## NANOMATERIALS - IRON (Compounds)

### Iron Nanoparticles

Note: Store at 5 to 25°C. Do not freeze. Suggested use within 12 months of receipt. Sold in collaboration with Cerion for research purposes only.

25g  
100g  
500g

**26-2758 Iron(III) oxyhydroxide in water at pH = 3.0 +/- 0.5 (FEO-W320) (20344-49-4)**

HAZ FeO(OH); FW: 88.85; d. 1.19  
(store cold)

% Solids: 20.0 +/- 0.5 as Fe<sub>2</sub>O<sub>3</sub>

pH: 3.0 +/- 0.5

Mean Number Weighted Particle Diameter: <5.0 nm (by Dynamic Light Scattering)

Polydispersity Index: <0.25

Chemical Composition (particles): >99.5% FeOOH

### Iron Nanoparticles - Solid form (with amine surface functional group)

5mg  
25mg

Note: A water-soluble iron oxide nanoparticles with amphiphilic polymer and PEG coating. The reactive group is an amine.

**26-2711 Iron oxide nanoparticles in water, 10nm, with amine surface functional group (1317-61-9)**

Fe<sub>3</sub>O<sub>4</sub>; FW: 231.53; brown liq.

Technical Notes:

1. Zeta potential is -10mv to +10mV.
2. The organic layers consist of a monolayer of oleic acid and a monolayer of amphiphilic polymer.
3. The overall thickness of the organic layers about 6 nm.
4. The hydrodynamic size of the nanoparticles is about 12-14 nm larger than their inorganic core size measured by TEM.
5. Very stable in most buffer solutions in the pH range of 4-10. Solution can survive autoclaving process (121°C for 30 minutes).
6. Light precipitation may occur during storage. Check expiration date before conjugation.
7. The amine density is low due to the long PEG chain.
8. Can be conjugated to carbonyl or thio-containing molecules.

References:

1. *Clinical Cancer Research*, **2009**, 15, 4722
2. *Gastroenterology*, **2009**, 136, 1514
3. *Small*, **2009**, 5, 235
4. *The Analysis*, **2008**, 133, 154
5. *The Journal of Physical Chemistry C*, **2008**, 112, 8127
6. *International Journal of Nanomedicine*, **2008**, 3, 311
7. *Journal of Biomedical Nanotechnology*, **2008**, 4, 439

**26-2713 Iron oxide nanoparticles in water, 20nm, with amine surface functional group (1317-61-9)**

Fe<sub>3</sub>O<sub>4</sub>; FW: 231.53; black liq.

Technical Note:

1. See 26-2711 (page 44)

**26-2715 Iron oxide nanoparticles in water, 30nm, with amine surface functional group (1317-61-9)**

Fe<sub>3</sub>O<sub>4</sub>; FW: 231.53; black liq.

Technical Note:

1. See 26-2711 (page 44)

## NANOMATERIALS - IRON (Compounds)

<b>Iron Nanoparticles - Solid form (with carboxylic acid surface functional group)</b>	10mg
Note: A water-soluble iron oxide nanoparticles with amphiphilic polymer coating. The reactive group is a carboxylic acid.	50mg

**26-2705 Iron oxide nanoparticles in water, 10nm, with carboxylic acid surface functional group**  
(1317-61-9)  
 $\text{Fe}_3\text{O}_4$ ; FW: 231.53; brown liq.  
(store cold)

### Technical Notes:

1. Zeta potential of 26-2705 -30mv to -50mV.
2. The organic layers consist of a monolayer of oleic acid and a monolayer of amphiphilic polymer.
3. The overall thickness of the organic layers about 4 nm.
4. The hydrodynamic size of the nanoparticles is about 8-10 nm, larger than their inorganic core size measured by TEM.
5. Very stable in most buffer solutions in the pH range of 4-10. Solution can survive autoclaving process (121°C for 30 minutes).

### References:

1. *Clinical Cancer Research*, **2009**, 15, 4722
2. *Gastroenterology*, **2009**, 136, 1514
3. *Small*, **2009**, 5, 235
4. *The Analysis*, **2008**, 133, 154
5. *The Journal of Physical Chemistry C*, **2008**, 112, 8127
6. *International Journal of Nanomedicine*, **2008**, 3, 311
7. *Journal of Biomedical Nanotechnology*, **2008**, 4, 439

**26-2707 Iron oxide nanoparticles in water, 20nm, with carboxylic acid surface functional group**  
(1317-61-9)  
 $\text{Fe}_3\text{O}_4$ ; FW: 231.53; black liq.

### Technical Note:

1. See 26-2705 (page 45)

**26-2709 Iron oxide nanoparticles in water, 30nm, with carboxylic acid surface functional group**  
(1317-61-9)  
 $\text{Fe}_3\text{O}_4$ ; FW: 231.53; black liq.

### Technical Note:

1. See 26-2705 (page 45)

<b>Iron Nanoparticles - Solid form (organic solvent-dispersible)</b>	50mg
Note: A water-soluble iron oxide nanoparticles with amphiphilic polymer and PEG coating. No linkable reactive group on the surface.	500mg

**26-2728 Iron oxide nanoparticles, 10nm, organic solvent-dispersible (in chloroform)**  
(1317-61-9)  
 $\text{Fe}_3\text{O}_4$ ; FW: 231.53; black liq.

### Technical Notes:

1. Zeta potential is -10mv to 0.
2. Total thickness of organic layers is ~6 nm.
3. The hydrodynamic size of the nanoparticles is about 12-14 nm larger than their inorganic core size as measured by TEM.
4. The colloidal stability is exceptionally high.
5. Stable in most buffer solutions in the pH range of 4-10. Solution can survive autoclaving process (121°C for 30 minutes).

### References:

1. *Clinical Cancer Research*, **2009**, 15, 4722
2. *Gastroenterology*, **2009**, 136, 1514
3. *Small*, **2009**, 5, 235
4. *The Analysis*, **2008**, 133, 154
5. *The Journal of Physical Chemistry C*, **2008**, 112, 8127
6. *International Journal of Nanomedicine*, **2008**, 3, 311
7. *Journal of Biomedical Nanotechnology*, **2008**, 4, 439

**26-2730 Iron oxide nanoparticles, 20nm, organic solvent-dispersible (in chloroform)**  
(1317-61-9)  
 $\text{Fe}_3\text{O}_4$ ; FW: 231.53; black liq.

### Technical Note:

1. See 26-2728 (page 45)

**26-2732 Iron oxide nanoparticles, 30nm, organic solvent-dispersible (in chloroform)**  
(1317-61-9)  
 $\text{Fe}_3\text{O}_4$ ; FW: 231.53; black liq.

### Technical Note:

1. See 26-2728 (page 45)

## NANOMATERIALS - IRON (Compounds)

### Iron Nanoparticles - Solid Form (in water with PEG)

Note: A water-soluble iron oxide nanoparticles with amphiphilic polymer and PEG coating. No linkable reactive group on the surface.

5mg  
25mg

#### 26-2722 Iron oxide nanoparticles in water, 10nm, with PEG (1317-61-9)

Fe<sub>3</sub>O<sub>4</sub>; FW: 231.53; brown liq.

#### Technical Notes:

1. Zeta potential is -10mv to 0.
2. Total thickness of organic layers is ~6 nm.
3. The hydrodynamic size of the nanoparticles is about 12-14nm larger than their inorganic core size as measured by TEM.
4. The colloidal stability is exceptionally high.
5. Stable in most buffer solutions in the pH range of 4-10. Solution can survive autoclaving process (121°C for 30 minutes).

#### References:

1. *Clinical Cancer Research*, **2009**, 15, 4722
2. *Gastroenterology*, **2009**, 136, 1514
3. *Small*, **2009**, 5, 235
4. *The Analysis*, **2008**, 133, 154
5. *The Journal of Physical Chemistry C*, **2008**, 112, 8127
6. *International Journal of Nanomedicine*, **2008**, 3, 311
7. *Journal of Biomedical Nanotechnology*, **2008**, 4, 439

#### 26-2724 Iron oxide nanoparticles in water, 20nm, with PEG (1317-61-9)

Fe<sub>3</sub>O<sub>4</sub>; FW: 231.53; brown liq.

#### Technical Note:

1. See 26-2722 (page 46)

#### 26-2726 Iron oxide nanoparticles in water, 30nm, with PEG (1317-61-9)

Fe<sub>3</sub>O<sub>4</sub>; FW: 231.53; black liq.

#### Technical Note:

1. See 26-2722 (page 46)

## NANOMATERIALS - LEAD (Compounds)

### Lead Sulfide Quantum Dots

Note: Sold in collaboration with CAN for R&D purposes. Suggest use within 6 months of purchase.

Do not freeze. Store in DARK.

<b>82-1081</b> HAZ	<b>Lead sulfide CANDOT® quantum dot (PbS core - ~3nm), 10 mg/mL in toluene, 1000nm peak emission (1314-87-0)</b>	2ml 10ml
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PbS; FW: 239.25; dark-red liq.

<b>82-1083</b> HAZ	<b>Lead sulfide CANDOT® quantum dot (PbS core - ~4.5nm), 10 mg/mL in toluene, 1200nm peak emission (1314-87-0)</b>	1ml 5ml
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PbS; FW: 239.25; dark-red liq.

<b>82-1085</b> HAZ	<b>Lead sulfide CANDOT® quantum dot (PbS core - ~6nm), 10 mg/mL in toluene, 1400nm peak emission (1314-87-0)</b>	1ml 5ml
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PbS; FW: 239.25; dark-red liq.

<b>82-1090</b> HAZ	<b>Lead sulfide CANDOT® quantum dot (PbS core - ~8nm), 10 mg/mL in toluene, 1600nm peak emission (1314-87-0)</b>	1ml 5ml
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PbS; FW: 239.25; dark-red liq.

## NANOMATERIALS - MAGNESIUM (Compounds)

#### 12-1405 Magnesium oxide nanopowder (1309-48-4)

MgO; FW: 40.31; white pwdr.

Note: APS 20nm; SSA 50m<sup>2</sup>/g

25g  
100g

## NANOMATERIALS - NICKEL (Elemental Forms)

28-0008



**Nickel/tetra-n-octylammonium bromide colloid, purified (65-70% Ni) (7440-02-0)**

Ni/(C<sub>8</sub>H<sub>17</sub>)<sub>4</sub>NBr; 2.8 nm (average); black powdr.

pyrophoric

Note: Made to order. Suggest use within 3 months of receipt. Long term shelf life not established.

100mg

500mg

### Technical Note:

1. Soluble in THF, toluene, acetone and methylene chloride. Insoluble in ethanol, ether and pentane.

### References:

1. *J. Mol. Catal.*, **1994**, 86, 129
2. *Eur. J. Inorg. Chem.*, **2001**, 2455
3. *Catalysis and Electrocatalysis at Nanoparticles Surfaces*, Chapter 10, p. 343, 377. Marcel Dekker, NY, **2003**.
4. *Advanced Catalysts and Nanostructured Materials*, Chapter 7, Academic, Press, San Diego, **1996**, 165-196.

## NANOMATERIALS - PALLADIUM (Elemental Forms)

### Palladium Heterogeneous Catalyst

5g

25g

46-1710

**Palladium, 0.6% on activated carbon, 50% water-wet paste (NanoSelect LF 100)**

(7440-05-3)

black solid (d50=25 µm)

Note: Sold in collaboration with BASF for research purposes only. BASF Heterogeneous Catalyst Kit (96-6717) component. BASF Palladium Catalyst Kit (96-6719) component.

### Technical Note:

1. NanoSelect LF 100 is a lead-free, water-wet, catalyst containing metal crystallites sizes of around 7 nm, and a mean particle size of 25 microns. The metal crystallites are supported on a carbon powder. The presence of nanometer-sized metal particles greatly increases the metal surface area available per gram of catalyst, and boosts catalytic activity. The catalyst is recommended for use in hydrogenation reactions leading to the partial reduction of functional groups. It is specifically suited for the selective hydrogenation of alkynes to alkenes, with a high selectivity for cis-alkenes.

### Palladium Nanoparticles

(store cold)

25ml

100ml

46-0407

**Palladium Nanoparticles [PdNP: 2-4 nm (gum Arabic)] (7440-05-3)**

yellowish-brown liq.

**Properties:** Water soluble; **Size:** 2-4 nm; **Shape:** Sphere; **Specification:** Stable for 60 days.

Supplied in aqueous media, contains gum arabix stabilizer. Suitable for in vitro use and sensor design applications.

Suitable for spin coating, self-assembly and monolayer formation. Potential new Catalysts.

46-0409

**Palladium Nanoparticles [PdNP: 2-3 nm (Gelatin)] (7440-05-3)**

yellowish-brown liq.

**Properties:** Water soluble; **Size:** 2-3 nm; **Shape:** Sphere; **Specification:** Stable for 60 days.

Supplied in aqueous media, contains gelatin stabilizer. Suitable for in vitro use and sensor design applications.

Suitable for spin coating, self-assembly and monolayer formation. Potential new Catalysts.

### Palladium Nanoparticles - Surfactant and Reactant-Free (Pure), Manufactured via Laser Ablation

25ml

100ml

Note: Made to order. Manufactured by laser ablation. Store at room temperature (up to 25°C). Do not freeze. Shelf life 12 months. Sold in collaboration with Particular® for research purposes only.

46-0412

HAZ

**Palladium nanoparticles, pure, (<20nm) in acetone at 100mg/L**

**(surfactant and reactant-free) (7440-05-3)**

grey-brown liq.

46-4010

**Palladium nanoparticles, pure, (<20nm) in water at 100mg/L**

**(surfactant and reactant-free, stabilized with < 0.01 mmol/l of citrate) (7440-05-3)**

grey-brown liq.

46-4018

**Palladium nanoparticles, pure, (<20nm) in water at 500mg/L**

**(surfactant and reactant-free, stabilized with < 0.01 mmol/l of citrate) (7440-05-3)**

black liq.

46-0422

HAZ

**Palladium nanoparticles, pure, (50-70nm) in acetone at 100mg/L**

**(surfactant and reactant-free) (7440-05-3)**

grey liq.

Note: Particle size of 50-70 nm is measured via DLS, colloid may also contain significant fractions of smaller particles. \*\*\*Limited quantities available\*\*\*

# NANOMATERIALS - PALLADIUM (Compounds)

## Nickel/palladium Alloy Nanoparticle on Graphene

25mg  
100mg

### 28-0015 Nickel/palladium alloy nanoparticle on graphene

NEW

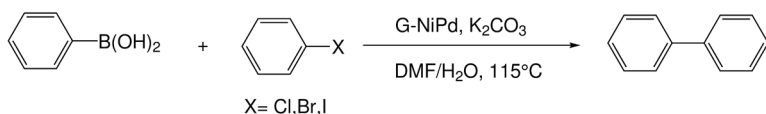
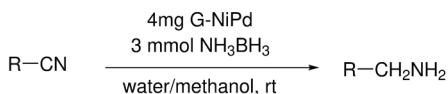
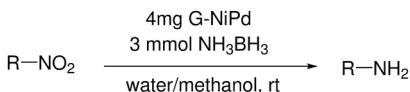
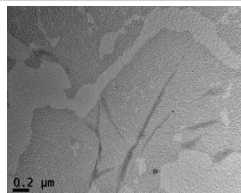
(G-Ni<sub>33</sub>Pd<sub>67</sub>)

black powdr.

Note: U.S. Patent Application 14/667,859.

#### Technical Note:

- NiPd NPs are useful catalysts for the tandem dehydrogenation of ammoniaborane and hydrogenation of R-NO<sub>2</sub> or R-CN to R-NH<sub>2</sub>. NiPd nanoparticles also catalyze Suzuki-Miyaura and Heck cross-coupling reactions. The product is synthesized via the borane reduction of nickel and palladium salts in oleylamine, followed by dispersing the resulting mixture of Ni/Pd nanoparticles on graphene. The catalyst is 100% recyclable and shows no drop in catalytic activity after one month, when stored in air or argon at ambient temperatures.



#### References:

- Nano Research*, **2013**, 6, 10.
- ACS Catal.*, **2014**, 4, 1777.



# NANOMATERIALS - PLATINUM (Compounds)

## Platinum Colloids

Note: Made to order. Suggest use within 3 months of receipt. Long term shelf life not established.

250mg

1g

78-0055

HAZ



**Platinum/tetra-n-octylammonium chloride colloid, purified (70-85% Pt)**  
(7440-06-4)

Pt/(C<sub>8</sub>H<sub>17</sub>)<sub>4</sub>NCl; 2.8 nm ±0.5 nm; grayish-black powd  
pyrophoric

Technical Note:

1. Soluble in THF. Insoluble in toluene, acetone, ether and ethanol.

References:

1. *J. Mol. Catal.*, **1994**, 86, 129
2. *Eur. J. Inorg. Chem.*, **2001**, 2455.
3. *Synthetic Methods of Organometallic and Inorganic Chemistry*, Vol.10, Chapter 20, p. 209-223, Theime Verlag, NY, 2002.
4. *Catalysis and Electrocatalysis at Nanoparticles Surfaces*, Chapter 10, p. 343, 377, Marcel Dekker, NY, 2003.

78-0062

HAZ

**Platinum-ruthenium/tetra-n-octylammonium chloride colloid**  
(~7 wt% Pt, ~3.5 wt% Ru) (7440-06-4)

Pt<sub>50</sub>Ru<sub>50</sub>/(C<sub>8</sub>H<sub>17</sub>)<sub>4</sub>NCl; 1.7 nm ±0.5 nm; waxy, black residue

Technical Note:

1. Very soluble in THF. Soluble in toluene. Precursor for fuel cell catalysts.

References:

1. *J. Mol. Catal.*, **1994**, 86, 129
2. *Synthetic Methods of Organometallic and Inorganic Chemistry*, Vol. 10, Chapter 20, p. 209-223, Theime Verlag, NY, 2002.
3. *Catalysis and Electrocatalysis at Nanoparticles Surfaces*, Chapter 10, p. 343-377, Marcel Dekker, NY, 2003.

## Platinum Fuel Cell Catalysts

100mg

78-1685

HAZ

**Dealloyed Pt-Co core-shell fuel cell catalyst on carbon**  
PtCo; black solid

Technical Note:

1. For detailed note visit [www.strem.com](http://www.strem.com).

78-1688

HAZ

**Dealloyed Pt-Cu core-shell fuel cell catalyst on carbon**  
PtCu; black solid

Technical Note:

1. For detailed note visit [www.strem.com](http://www.strem.com).

## Platinum Nanoparticles

78-0007

HAZ



**Platinum, 97% (2-5 nanometers)** (7440-06-4)

Pt; black powd.

pyrophoric

Note: Made to order. Suggest use within 3 months of receipt. Long term shelf life not established.

250mg

1g

References:

1. *J. Mol. Catal.*, **1994**, 86, 129

78-0405

**Platinum Nanoparticles [PtNP: 2-3 nm (gum Arabic)]** (7440-06-4)

yellowish-brown liq.

(store cold)

25ml

100ml

**Properties:** Water soluble; **Size:** 2-3 nm; **Shape:** Sphere; **UV Vis (nm):** 405-410 nm; **Specification:** Stable for 60 days  
Supplied in aqueous media, contains gum arabic stabilizer. Suitable for in vitro use and sensor design applications.  
Suitable for spin coating, self-assembly and monolayer formation. Potential new Catalysts.

## NANOMATERIALS - PLATINUM (Compounds)

### Platinum Nanoparticles - Surfactant and Reactant-Free (Pure), Manufactured via Laser Ablation

Note: Made to order. Manufactured by laser ablation. Store at room temperature (up to 25°C). Do not freeze. Shelf life 12 months. Sold in collaboration with Particular® for research purposes only.

78-1405	Platinum nanoparticles, pure, (<20nm) in water at 30mg/L (surfactant and reactant-free, stabilized with <0.01 mmol/l of citrate) (7440-06-4) grey-brown liq.	100ml
78-1402	Platinum nanoparticles, pure, (<20nm) in water at 100mg/L (surfactant and reactant-free, stabilized with < 0.01 mmol/l of citrate) (7440-06-4) grey-brown liq.	25ml 100ml
78-1404 HAZ	Platinum nanoparticles, pure, (<20nm) in acetone at 100mg/L (surfactant and reactant-free) (7440-06-4) grey-brown liq.	25ml 100ml
78-1408 HAZ	Platinum nanoparticles, pure, (<20nm) in isopropanol at 100mg/L (surfactant and reactant-free) (7440-06-4) grey-brown liq.	25ml 100ml
78-1410	Platinum nanoparticles, pure, (<20nm) in water at 500mg/L (surfactant and reactant-free, stabilized with < 0.01 mmol/l of citrate) (7440-06-4) black liq.	25ml 100ml
78-1414 HAZ	Platinum nanoparticles, pure, (50-70nm) in acetone at 100mg/L (surfactant and reactant-free) (7440-06-4) grey liq. Note: Particle size of 50-70 nm is measured via DLS, colloid may also contain significant fractions of smaller particles. ***Limited quantities available***	25ml 100ml

### Platinum Nanoparticles - Surfactant and Reactant-Free (Supported), Manufactured via Laser Ablation

(store cold) Note: Manufactured by laser ablation. Sold in collaboration with Particular® for research purposes only.

78-3015	Platinum nanoparticles, 1% on carbon black (surfactant and reactant-free) (7440-06-4) Pt; FW: 195.10; black solid	5g 25g
78-3020	Platinum nanoparticles, 5% on carbon black (surfactant and reactant-free) (7440-06-4) Pt; FW: 195.10; black solid	5g 25g
78-3030	Platinum nanoparticles, 10% on carbon black (surfactant and reactant-free) (7440-06-4) Pt; FW: 195.10; black solid	1g 5g
78-3032	Platinum nanoparticles, 20% on carbon black (surfactant and reactant-free) (7440-06-4) Pt; FW: 195.10; black solid	1g 5g
78-3035	Platinum nanoparticles, 30% on carbon black (surfactant and reactant-free) (7440-06-4) Pt; FW: 195.10; black solid	1g 5g
78-3012	Platinum nanoparticles, 1% on Titania (anatase) (surfactant and reactant-free) (7440-06-4) Pt; FW: 195.10; gray solid	5g 25g
78-3005	Platinum nanoparticles, 1% on Titania (anatase/rutile) (surfactant and reactant-free) (7440-06-4) Pt; FW: 195.10; light gray solid	5g 25g
78-3026	Platinum nanoparticles, 10% on Titania (anatase) (surfactant and reactant-free) (7440-06-4) Pt; FW: 195.10; dark gray solid	1g 5g
78-3023	Platinum nanoparticles, 10% on Titania (anatase/rutile) (surfactant and reactant-free) (7440-06-4) Pt; FW: 195.10; dark gray solid	1g 5g

## NANOMATERIALS - RHODIUM (Compounds)

### Rhodium Colloids

Note: Made to order. Suggest use within 3 months of receipt. Long term shelf life not established.


<b>45-1550</b>	<b>Rhodium colloid (polyethyleneglycol-dodecylether hydrosol) (~9 wt% Rh)</b>	1g
	(7440-16-6)	5g
	Rh/alkoxyethers; ~2 nm; brown-black viscous substance	
	Note: *Limited quantities available*	

Technical Note:

1. Soluble in ether, alcohol, and water.

References:

1. *Eur. J. Inorg. Chem.*, **2001**, 2455

<b>45-1660</b>	<b>Rhodium/tetra-n-octylammonium chloride colloid, purified (70-75% Rh)</b>	250mg
HAZ	(7440-16-6)	1g
	Rh/(C <sub>8</sub> H <sub>17</sub> ) <sub>4</sub> NCl; 2.0 nm ±0.5 nm; gray powder	
	pyrophoric	

Technical Note:

1. Very soluble in THF, soluble in acetone, slightly soluble in toluene, insoluble in ether.

References:

1. *J. Mol. Catal.*, **1994**, 86, 129
2. *Eur. J. Inorg. Chem.*, **2001**, 2455
3. *Catalysis and Electrocatalysis at Nanoparticles Surfaces, Chapter 10*, p. 343-377. Marcel Dekker, NY, **2003**.
4. *Advanced Catalysts and Nanostructured Materials, Chapter 7*, Academic, Press, San Diego, **1996**, 165-196.

### Rhodium Nanoparticles - Surfactant and Reactant-Free (Pure),

25ml

#### Manufactured via Laser Ablation

100ml

Note: Made to order. Manufactured by laser ablation. Store at room temperature (up to 25°C).

Do not freeze. Shelf life 12 months. Sold in collaboration with Particular® for research purposes only.

<b>45-1324</b>	<b>Rhodium nanoparticles, pure, (&lt;20nm) in acetone at 100mg/L (surfactant and reactant-free) (7440-16-6)</b>
HAZ	grey-brown liq.

<b>45-1328</b>	<b>Rhodium nanoparticles, pure, (&lt;20nm) in isopropanol at 100mg/L (surfactant and reactant-free) (7440-16-6)</b>
HAZ	grey-brown liq.

<b>45-1322</b>	<b>Rhodium nanoparticles, pure, (&lt;20nm) in water at 100mg/L (surfactant and reactant-free, stabilized with &lt; 0.01 mmol/l of citrate) (7440-16-6)</b>
	grey-brown liq.

<b>45-1330</b>	<b>Rhodium nanoparticles, pure, (&lt;20nm) in water at 500mg/L (surfactant and reactant-free, stabilized with &lt; 0.01 mmol/l of citrate) (7440-16-6)</b>
	black liq.

## NANOMATERIALS - RUTHENIUM (Elemental Forms)

### Ruthenium Nanoparticles - Surfactant and Reactant-Free (Pure),

25ml

#### Manufactured via Laser Ablation

100ml

Note: Made to order. Manufactured by laser ablation. Store at room temperature (up to 25°C).

Do not freeze. Shelf life 12 months. Sold in collaboration with Particular® for research purposes only.

<b>44-2812</b>	<b>Ruthenium nanoparticles, pure, (&lt;20nm) in acetone at 100mg/L (surfactant and reactant-free) (7440-18-8)</b>
HAZ	grey-brown liq.
	Note: ***Limited quantities available***

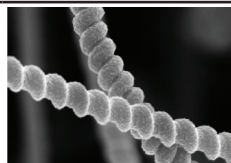
<b>44-2822</b>	<b>Ruthenium nanoparticles, pure, (50-70nm) in acetone at 100mg/L (surfactant and reactant-free) (7440-18-8)</b>
HAZ	grey liq.
	Note: Particle size of 50-70 nm is measured via DLS, colloid may also contain significant fractions of smaller particles. ***Limited quantities available***

## NANOMATERIALS - SILICON (Elemental Forms)

<b>14-0655</b>	<b>Silicon powder (amorphous), min. 97% (7440-21-3)</b>	5g
HAZ	Si; brown powder; SA: >50 m <sup>2</sup> /g	25g
	air sensitive	

## NANOMATERIALS - SILICON (Elemental Forms)

<b>14-0650</b>	<b>Silicon powder (nanocrystalline), min. 97% (7440-21-3)</b>	5g
HAZ	Si; brown powdr.; SA: <20 m <sup>2</sup> /g <i>air sensitive</i>	25g
<b>14-6052</b>	<b>Silica Nanosprings™ coated with zinc oxide and grown on fiber glass substrate (3.5 x 8cm) (7631-86-9)</b> white to beige plate Note: ***Limited quantities available.***	1pc



## NANOMATERIALS - SILICON (Compounds)

### High Surface Area Silica Nanoparticles (112945-52-5)

Note: This product is under license of patented Technology from King Abdullah University of Science and Technology – KAUST. Patent PCT/IB2010/002421.

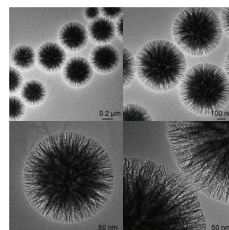
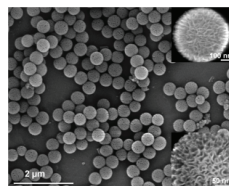
<b>14-6100</b>	<b>High Surface area Silica nanoparticles, large, particle size ~900-1000 nm, surface area ~700 m<sup>2</sup>/g, (KCC-1 L1) (112945-52-5)</b>	1g
<b>NEW</b>	SiO <sub>2</sub> ; FW: 60.09; white powdr.; SA: ~700 m <sup>2</sup> /g; P.Vol. ~1.4 cm <sup>3</sup> /g Note: Diameter: 900-1000nm	5g

#### Technical Note:

- Novel fibrous shaped silica nanospheres, denoted as KCC-1 (KAUST Catalysis Center)<sup>[1]</sup>, have unique physical properties which have never before been reported in silica materials. These nanomaterials have been developed by Prof. J. M. Basset of King Abdullah University of Science and Technology (KAUST). A fibrous surface morphology arranged in three-dimensional structure forms the spheres (Fig. 1). Unlike traditional pore-based silica, these nanospheres possess a fibrous structure that increases accessibility to the available surface area; this in turn, significantly increases the catalytic activity.

These materials exhibit excellent physical properties, including a high surface area, a fibrous surface morphology, good thermal and hydrothermal stabilities and high mechanical stability (Table 1). The fibrous morphology of KCC-1 remains unaffected even after mechanical compression up to 216 MPa pressure. This is superior to the conventional MCM-41 type of silica, which is affected at pressure 86 MPa.<sup>[1]</sup>

A range of heterogeneous catalysts, prepared using KCC-1 as a supporting material, have been showing excellent catalytic activity for various transformations of research and industrial importance. As a catalyst support, sorbent or carrier, KCC-1 is able to demonstrate superior activity as compared to regular mesoporous silica materials in energy related processes<sup>[2-3]</sup>, a variety of organic reactions<sup>[4-7]</sup>, biomedical applications and drug delivery systems<sup>[8]</sup>, optoelectronic devices<sup>[9]</sup> and many others.



Product #	Category	Grade	Particle Size (nm)	Surface Area (m <sup>2</sup> /g)	Pore Volume (cm <sup>3</sup> /g)
14-6100	Large	(KCC-1 L1)	~900-1000	~700	~1.4
14-6110	Large	(KCC-1 L2)	~900-1000	~600	~1.2
14-6120	Large	(KCC-1 L3)	~900-1000	~550	~0.9
14-6200	Medium	(KCC-1 M1)	~400-450	~400	~0.7
14-6210	Medium	(KCC-1 M2)	~300-350	~600	~0.6
14-6300	Small	(KCC-1 S1)	~130-190	~380	~0.8
14-6310	Small	(KCC-1 S2)	~40-50	~520	~1.3

#### References:

- Angew. Chem. Int. Ed. **2010**, 49, 9652
- Chem. Mater. **2015**, 27, 8237
- ACS Catalysis. **2016**, 6, 2770
- ChemSusChem **2012**, 5, 85
- Green Chem., **2016**, 18, 5890
- Angew. Chem. Int. Ed. **2011**, 50, 2747
- RSC Adv., **2017**, 7, 24885
- Langmuir **2014**, 30, 10886
- J. Mater. Chem. B, **2015**, 3, 3201

## NANOMATERIALS - SILICON (Compounds)

<b>14-6110</b>	<b>High Surface area Silica nanoparticles, large, particle size ~900-1000 nm, surface area ~600 m<sup>2</sup>/g, (KCC-1 L2) (112945-52-5)</b>	1g
<b>NEW</b>	SiO <sub>2</sub> ; FW: 60.09; white powdr.; SA: ~600 m <sup>2</sup> /g; P.Vol. ~1.20 cm <sup>3</sup> /g	5g
	Note: Diameter: ~900-1000nm	

Technical Note:

1. See 14-6100 (page 52)

<b>14-6120</b>	<b>High Surface area Silica nanoparticles, large, particle size ~900-1000 nm, surface area ~550 m<sup>2</sup>/g (KCC-1 L3) (112945-52-5)</b>	1g
<b>NEW</b>	SiO <sub>2</sub> ; FW: 60.09; white powdr.; SA: ~550 m <sup>2</sup> /g; P.Vol. ~0.97 cm <sup>3</sup> /g	5g
	Note: Diameter: ~900-1000nm	

Technical Note:

1. See 14-6100 (page 52)

<b>14-6200</b>	<b>High Surface area Silica nanoparticles, medium, particle size ~400-450 nm, surface area ~400 m<sup>2</sup>/g, (KCC-1 M1) (112945-52-5)</b>	1g
<b>NEW</b>	SiO <sub>2</sub> ; FW: 60.09; white powdr.; SA: ~400 m <sup>2</sup> /g; P.Vol. ~0.7 cm <sup>3</sup> /g	5g
	Note: Diameter: ~400-450nm	

Technical Note:

1. See 14-6100 (page 52)

<b>14-6210</b>	<b>High Surface area Silica nanoparticles, medium, particle size ~300-350 nm, surface area ~600 m<sup>2</sup>/g, (KCC-1 M2) (112945-52-5)</b>	1g
<b>NEW</b>	SiO <sub>2</sub> ; FW: 60.09; white powdr.; SA: ~600 m <sup>2</sup> /g; P.Vol. ~0.6 cm <sup>3</sup> /g	5g
	Note: Diameter: ~300-350nm	

Technical Note:

1. See 14-6100 (page 52)

<b>14-6300</b>	<b>High Surface area Silica nanoparticles, small, particle size ~130-190 nm, surface area ~380 m<sup>2</sup>/g, (KCC-1 S1) (112945-52-5)</b>	1g
<b>NEW</b>	SiO <sub>2</sub> ; FW: 60.09; white to beige powdr.; SA: ~380 m <sup>2</sup> /g; P.Vol. ~0.8 cm <sup>3</sup> /g	5g
	Note: Diameter: ~130-190nm	

Technical Note:

1. See 14-6100 (page 52)

<b>14-6310</b>	<b>High Surface area Silica nanoparticles, small, particle size ~40-50 nm, surface area ~520 m<sup>2</sup>/g, (KCC-1 S2) (112945-52-5)</b>	250mg
<b>NEW</b>	SiO <sub>2</sub> ; FW: 60.09; white to beige powdr.; SA: 520 m <sup>2</sup> /g; P.Vol. 1.3 cm <sup>3</sup> /g	1g
	Note: Diameter: 40-50 nm	5g

Technical Note:

1. See 14-6100 (page 52)

<b>96-5050</b>	<b>High Surface Area Silica Nanoparticles Kit</b>
	See page 63

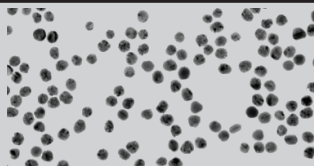
## NANOMATERIALS - SILVER (Elemental Forms)

### Silver Nanoparticles - in citrate buffer

light sensitive, (store cold)

Note: Store away from direct sunlight at 4°C.

Do not freeze. Shelf life 6 months.



20ml  
100ml

Technical Note:

Product #	Diameter	Color and form	Absorption max
<b>47-0620</b>	10nm	yellow liq.	390-400nm
<b>47-0623</b>	20nm	yellow liq.	405nm
<b>47-0626</b>	30nm	yellow liq.	410nm
<b>47-0630</b>	40nm	yellow liq.	416nm
<b>47-0633*</b>	50nm	yellow liq.	425nm
<b>47-0635</b>	60nm	yellow liq.	430nm
<b>47-0638</b>	80nm	yellow liq.	457nm
<b>47-0640</b>	100nm	yellow liq.	490nm

## NANOMATERIALS - SILVER (Elemental Forms)

### Silver Nanoparticles - Reactant-Free

*light sensitive, (store cold)*

Note: Store away from direct sunlight at 4°C. Do not freeze. Shelf life 6 months.

Technical Note:

20ml  
100ml

Product #	Diameter	Color and form	Absorption max
47-0655	10nm	yellow liq.	390-400nm
47-0658	20nm	yellow liq.	405nm
47-0660	30nm	yellow liq.	410nm
47-0663	40nm	yellow liq.	416nm
47-0665	50nm	yellow liq.	425nm
47-0668	60nm	yellow liq.	430nm
47-0670	80nm	yellow liq.	457nm
47-0672	100nm	yellow liq.	490nm

### Silver Nanoparticles - Surfactant and Reactant-Free (Pure),

#### Manufactured via Laser Ablation

Note: Made to order. Manufactured by laser ablation. Store at room temperature (up to 25°C).

Do not freeze. Shelf life 12 months. Sold in collaboration with Particular® for research purposes only.

25ml  
100ml

47-0712 HAZ	Silver nanoparticles, pure, (<20nm) in acetone at 100mg/L (surfactant and reactant-free) (7440-22-4) yellowish-brown liq.
47-0710	Silver nanoparticles, pure, (<20nm) in water at 100mg/L (surfactant and reactant-free, stabilized with < 0.01 mmol/l of citrate) (7440-22-4) yellow liq.
47-0718	Silver nanoparticles, pure, (<20nm) in water at 500mg/L (surfactant and reactant-free, stabilized with < 0.01 mmol/l of citrate) (7440-22-4) yellowish-grey liq.
47-0722 HAZ	Silver nanoparticles, pure, (50-70nm) in acetone at 100mg/L (surfactant and reactant-free) (7440-22-4) yellowish-brown liq. Particle size of 50-70 nm is measured via DLS, colloid may also contain significant fractions of smaller particles. ***Limited quantities available***

## NANOMATERIALS - TIN (Compounds)

50-0518	Tin(IV) oxide, nanoparticle (30-60 nm), (99.7%-Sn) (18282-10-5) SnO <sub>2</sub> ; FW: 150.69; white pwd.; SA: 18.55 m <sup>2</sup> /g; m.p. 1630°; d. 6.95
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25g  
100g

## NANOMATERIALS - TITANIUM (Elemental Forms)

### Titanium Nanoparticles - Surfactant and Reactant-Free (Pure),

#### Manufactured via Laser Ablation

Note: Made to order. Manufactured by laser ablation. Store at room temperature (up to 25°C). Do not freeze. Shelf life 12 months. Sold in collaboration with Particular® for research purposes only.

22-0192 HAZ	Titanium nanoparticles, pure, (<20nm) in acetone at 100mg/L (surfactant and reactant-free) (7440-32-6) grey liq. Note: ***Limited quantities available***	25ml 100ml
22-0198	Titanium nanoparticles, pure, (50-70nm) in ethylene glycol at 100mg/L (surfactant and reactant-free) (7440-32-6) grey liq. Note: Particle size of 50-70 nm is measured via DLS, colloid may also contain significant fractions of smaller particles. ***Limited quantities available***	25ml

## NANOMATERIALS - TITANIUM (Elemental Forms)

22-0203 HAZ	<b>Titanium nanoparticles, pure, (50-70nm) in isopropanol at 100 mg/L (surfactant and reactant-free) (7440-32-6)</b> grey liq. Note: Particle size of 50-70 nm is measured via DLS, colloid may also contain significant fractions of smaller particles. ***Limited quantities available***	100ml
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## NANOMATERIALS - TITANIUM (Compounds)

22-1400	<b>Titanium(IV) oxide nanopowder Anatase (1317-80-2)</b> TiO <sub>2</sub> ; FW: 79.90; white powdr.	25g 25g
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**Specific Surface Area (BET):** ≥500 m<sup>2</sup>/g; **True Density:** 3.7 g/cc; **Crystallite Size:** Amorphous; **Mean Aggregate Size:** 5 μm; **Average Pore Diameter:** 32Å; **Loss on Ignition:** ≤12%; **Total Pore Volume:** ≥0.4 cc/g; **Moisture Content:** ≤4%; **Bulk Density:** 0.6 g/cc; **Ti Content (Based on Metal):** > 99.999%

## NANOMATERIALS - ZINC (Compounds)

30-1405	<b>Zinc oxide nanopowder (1314-13-2)</b> ZnO; FW: 81.37; white powdr.	25g 100g
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## NANOMATERIALS - OTHER

96-0900	<b>Enzymatic Flow Reactor (2.5 inch tube x 0.25 inch I.D.)</b>	1ea
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### Technical Note:

The EFR is a 2.5 inch long, 0.25 inch i.d. tube that is packed with stainless steel mesh coated with a total of approximately 50mg of silica nanosprings.

The surfaces of these nanosprings are functionalized with free sulfhydryl groups at the end of a three carbon chain that can react with an appropriately activated enzyme.

## NANOMATERIALS (Surfactants & Ligands for Nano Synthesis)

07-0440	<b>L-Cysteine ethyl ester hydrochloride, 98% (868-59-7)</b> HSCH <sub>2</sub> CH(NH <sub>2</sub> )COOC <sub>2</sub> H <sub>5</sub> ·HCl; FW: 185.67; white solid; m.p. 123-125° Note: Surfactant for nanomaterial synthesis.	25g 100g
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02-5043	<b>3-(Decyldimethylammonio)propanesulfonate (Sulfobetaine 10) (15163-36-7)</b> [CH <sub>3</sub> (CH <sub>2</sub> ) <sub>9</sub> N <sup>+</sup> ][(CH <sub>3</sub> ) <sub>2</sub> (CH <sub>2</sub> ) <sub>3</sub> SO <sub>3</sub> <sup>-</sup> ]; FW: 307.49; white solid Note: Surfactant for nanomaterial synthesis.	1g 5g
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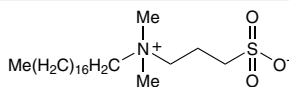
07-1677	<b>Didodecylamine, min. 97% (3007-31-6)</b> [CH <sub>3</sub> (CH <sub>2</sub> ) <sub>10</sub> CH <sub>2</sub> ] <sub>2</sub> NH <sub>2</sub> ; FW: 353.67; white xtl. Note: Surfactant for nanomaterial synthesis.	1g
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02-5055	<b>N-Dodecyl-N,N-dimethyl-3-ammonio-1-propanesulfonate (Sulfobetaine 12) (14933-08-5)</b> CH <sub>3</sub> (CH <sub>2</sub> ) <sub>11</sub> N <sup>+</sup> (CH <sub>3</sub> ) <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> SO <sub>3</sub> <sup>-</sup> ; FW: 335.55; white powdr. Note: Surfactant for nanomaterial synthesis.	10g 50g
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02-5045 HAZ	<b>Hexadecyltrimethylammonium bromide, 99+% CTAB (57-09-0)</b> [CH <sub>3</sub> (CH <sub>2</sub> ) <sub>15</sub> N(CH <sub>3</sub> ) <sub>3</sub> <sup>+</sup> Br <sup>-</sup> ]; FW: 364.45; white solid; m.p. 248-251° Note: Surfactant for nanomaterial synthesis.	50g 250g
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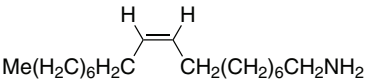
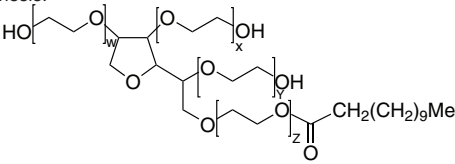
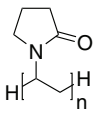
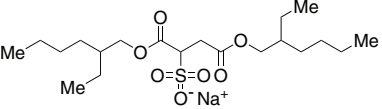
03-1180	<b>Lithium dodecyl sulfate, min. 98% (2044-56-6)</b> CH <sub>3</sub> (CH <sub>2</sub> ) <sub>11</sub> OSO <sub>3</sub> <sup>-</sup> Li <sup>+</sup> ; FW: 272.33; white solid Note: Surfactant for nanomaterial synthesis.	1g 5g
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02-5056	<b>N-Octyldodecyl-N,N-dimethyl-3-ammonio-1-propanesulfonate (Sulfobetaine 18) (13177-41-8)</b> Me(CH <sub>2</sub> ) <sub>17</sub> N(Me) <sub>2</sub> (CH <sub>2</sub> ) <sub>3</sub> SO <sub>3</sub> <sup>-</sup> FW: 419.70; white solid Note: Surfactant for nanomaterial synthesis.	5g 25g
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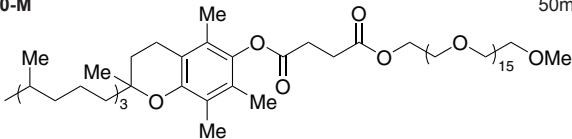
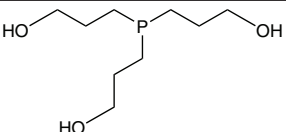




# NANOMATERIALS (Surfactants & Ligands for Nano Synthesis)

06-4010	<b>Oleic acid, 99% (112-80-1)</b> $\text{CH}_3(\text{CH}_2)_7=\text{CH}(\text{CH}_2)_7\text{COOH}$ ; FW: 282.46; liq.; m.p. 13°; b.p. 194-195° (1.2mm); d. 0.89 Note: Surfactant for nanomaterial synthesis.	5g 25g
07-1665	<b>Oleylamine, min. 70% (112-90-3)</b> $\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{CH}_2\text{NH}_2$ ; FW: 267.49; colorless liq.; m.p. 18-26°; b.p. 348-350°; d. 0.813 Note: Surfactant for nanomaterial synthesis.	5g 25g
07-1668	<b>Oleylamine, min. 95% (112-90-3)</b> $\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{CH}_2\text{NH}_2$ ; FW: 267.49; colorless liq.; m.p. 18-26°; b.p. 348-350°; d. 0.813 Note: Surfactant for nanomaterial synthesis.	5g 25g
		
09-5950	<b>Perfluorotetradecanoic acid, min. 97% (376-06-7)</b> $\text{CF}_3(\text{CF}_2)_{12}\text{COOH}$ ; FW: 714.11; white solid; m.p. 130-135°; b.p. 270° (740mm); d. 0.89 Note: Surfactant for nanomaterial synthesis.	1g
06-5075	<b>Polyethylene glycol dodecyl ether (Brij™ 35) (9002-92-0)</b> $\text{CH}_3(\text{CH}_2)_{10}\text{CH}_2(\text{OCH}_2\text{CH}_2)_n\text{OH}$ (n~23); FW: ~1199.54; liq. (white solid @ room temperature); m.p. 41-45° Note: Surfactant for nanomaterial synthesis.	250g 1kg
08-1650	<b>Polyethylene glycol sorbitan monolaurate (TWEEN® 20) (9005-64-5)</b> FW: ~1228; viscous liq.; d. 1.095 Note: Surfactant for nanomaterial synthesis.	5g 25g
		
07-1815	<b>Polyvinylpyrrolidone (average mol. Wt. 10,000) PVP10 (9003-39-8)</b> $(\text{C}_6\text{H}_9\text{NO})_n$ ; white powdr. Note: Surfactant for nanomaterial synthesis.	50g 250g
		
07-1817	<b>Polyvinylpyrrolidone (average mol.wt. 40,000) PVP40 (9003-39-8)</b> $(\text{C}_6\text{H}_9\text{NO})_n$ ; white powdr. Note: Surfactant for nanomaterial synthesis.	50g 250g
11-2750	<b>Sodium dioctylsulfosuccinate (AOT), min. 95% (577-11-7)</b> $\text{C}_{20}\text{H}_{37}\text{N}_2\text{O}_7\text{S}$ ; FW: 444.56; white powdr.; m.p. 176° Note: Surfactant for nanomaterial synthesis.	50g 250g
		
11-1140	<b>Sodium dodecylsulfate, 98+% (151-21-3)</b> $\text{CH}_3(\text{CH}_2)_{11}\text{OSO}_3\text{Na}$ ; FW: 288.38; white xtl.; m.p. 204-207°	25g 100g
11-1285	<b>Sodium dodecylsulfate, min. 99% (151-21-3)</b> $\text{CH}_3(\text{CH}_2)_{11}\text{OSO}_3\text{Na}^+$ ; FW: 288.38; white solid; m.p. 204-207° Note: Surfactant for nanomaterial synthesis.	50g 250g
11-1280	<b>Sodium oleate, 99% (143-19-1)</b> $\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{COO}^-\text{Na}^+$ ; FW: 304.44; white powdr.; m.p. 232-235° Note: Surfactant for nanomaterial synthesis.	5g 25g
02-5065	<b>Tetramethylammonium hydroxide pentahydrate, min. 95% (10424-65-4)</b> $(\text{CH}_3)_4\text{N}(\text{OH})\cdot 5\text{H}_2\text{O}$ ; FW: 181.23; white solid; m.p. 67-70° Note: Surfactant for nanomaterial synthesis.	10g 50g

# NANOMATERIALS (Surfactants & Ligands for Nano Synthesis)

02-5040	<b>Tetraoctylammonium chloride, min. 97% (3125-07-3)</b> [CH <sub>3</sub> (CH <sub>2</sub> ) <sub>7</sub> ] <sub>4</sub> N <sup>+</sup> Cl <sup>-</sup> ; FW: 502.34; white xtl. Note: Surfactant for nanomaterial synthesis.	1g
08-2180	<b>DL-α-Tocopherol methoxypolyethylene glycol succinate solution (2 wt% in water) TPGS-750-M</b> C <sub>66</sub> H <sub>117</sub> O <sub>21</sub> ; FW: 1246.62; colorless liq. Note: Surfactant for nanomaterial synthesis.	10ml 50ml
		
<b>Technical Notes:</b> 1. Visit <a href="http://strem.com">strem.com</a> for full technical note.		
15-6655 HAZ	<b>Tri-n-octylphosphine, min. 97% TOP (4731-53-7)</b> (C <sub>8</sub> H <sub>17</sub> ) <sub>3</sub> P; FW: 370.60; colorless to pale yellow liq.; m.p. 30°; b.p. 175°/0.3mm; f.p. 280°F; d. 0.83 <i>air sensitive</i> Note: Surfactant for nanomaterial synthesis.	25g 100g 500g
15-6660 HAZ	<b>Trioctylphosphine oxide, min. 90% TOPO (78-50-2)</b> (n-C <sub>8</sub> H <sub>17</sub> ) <sub>3</sub> PO; FW: 386.65; off-white xtl.; m.p. 51-52°; f.p. >230°F; d. 0.88 <i>hygroscopic</i> Note: Surfactant for nanomaterial synthesis.	100g 500g
15-6661 HAZ	<b>Trioctylphosphine oxide, 99% TOPO (78-50-2)</b> (n-C <sub>8</sub> H <sub>17</sub> ) <sub>3</sub> PO; FW: 386.65; white to off-white solid; m.p. 51-52°; f.p. >230°F; d. 0.88 <i>hygroscopic</i> Note: Surfactant for nanomaterial synthesis.	25g 100g
15-6375 amp HAZ	<b>Tris(3-hydroxypropyl)phosphine, min. 80% (4706-17-6)</b> (HOC <sub>3</sub> H <sub>6</sub> ) <sub>3</sub> P; FW: 208.24; viscous liq. <i>air sensitive</i> Note: Surfactant for nanomaterial synthesis.	2g 10g 50g
		

## KITS - CADMIUM SELENIDE StremDots™ QUANTUM DOT (CdSe core) KIT

**96-0800**  
HAZ **Cadmium selenide StremDots™ quantum dot (CdSe core) kit, 50umol/L in hexanes, 525-625nm peak emissions**  
Components also available for individual sale.  
Contains the following:

48-1011	Cadmium selenide StremDots™ quantum dot (CdSe core), 50umol/L in hexanes, 525nm peak emission (1306-24-7)	5ml	See page 22
48-1017	Cadmium selenide StremDots™ quantum dot (CdSe core), 50umol/L in hexanes, 550nm peak emission (1306-24-7)	5ml	See page 22
48-1023	Cadmium selenide StremDots™ quantum dot (CdSe core), 50umol/L in hexanes, 575nm peak emission (1306-24-7)	5ml	See page 22
48-1030	Cadmium selenide StremDots™ quantum dot (CdSe core), 50umol/L in hexanes, 600nm peak emission (1306-24-7)	5ml	See page 22
48-1035	Cadmium selenide StremDots™ quantum dot (CdSe core), 50umol/L in hexanes, 625nm peak emission (1306-24-7)	5ml	See page 22

Item #	Peak Emission	Particle size (diameter)	Quantum Yield
48-1011	525nm	2.8nm	>20%
48-1017	550nm	3.5nm	>10%
48-1023	575nm	3.9nm	>10%
48-1030	600nm	4.7nm	>20%
48-1035	625nm	5.3nm	>20%

Kit contains 5ml of each of the above 5 products. Ligand capping agent oleylamine. Stable in dispersions > 6 months.  
\*Particle size reported excludes ligand capping agent. All sizes determined by TEM.  
† Available at nanoparticle concentration of 50µmol per liter.

## KITS - CADMIUM SELENIDE/CADMIUM SULFIDE StremDots™ QUANTUM ROD KIT

**96-0813**  
HAZ **Cadmium selenide/cadmium sulfide StremDots™ quantum rod kit (CdSe/CdS elongated core/shell), 5 mg/ml in hexanes, 560nm, 590nm, 620nm peak emissions**  
Components also available for individual sale.  
Contains the following:

48-1053	Cadmium selenide/cadmium sulfide StremDots™ quantum rod (CdSe/CdS elongated core/shell), 5 mg/ml in hexanes, 560nm peak emission (1306-24-7)	0.5ml	See page 22
48-1056	Cadmium selenide/cadmium sulfide StremDots™ quantum rod (CdSe/CdS elongated core/shell), 5 mg/ml in hexanes, 590nm peak emission (1306-24-7)	0.5ml	See page 22
48-1059	Cadmium selenide/cadmium sulfide StremDots™ quantum rod (CdSe/CdS elongated core/shell), 5 mg/ml in hexanes, 620nm peak emission (1306-24-7)	0.5ml	See page 22

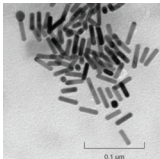
## KITS - GOLD GEMINI NANORODS KIT (CTAB FREE)

**96-1549 Gold Gemini Nanorods Kit, CTAB Free (Wavelength 650-850 nm)**  
 Rods are synthesized without CTAB. Store at 4°C - 8°C. Do not freeze.  
 At storage temperature the product may appear opaque. Follow the procedure for re-dispersing surfactants as described in the technical note. Complete this process before use to dissolve precipitated stabilizer.  
 Sold in collaboration with SONA Nanotech for research purposes only.  
 Components also available for individual sale.  
 Contains the following:

79-7010	Gold Gemini Nanorods, CTAB Free (Wavelength 650 nm) (7440-57-5)	5ml	See page 42
79-7015	Gold Gemini Nanorods, CTAB Free (Wavelength 700 nm) (7440-57-5)	5ml	See page 42
79-7020	Gold Gemini Nanorods, CTAB Free (Wavelength 750 nm) (7440-57-5)	5ml	See page 42
79-7025	Gold Gemini Nanorods, CTAB Free (Wavelength 800 nm) (7440-57-5)	5ml	See page 42
79-7030	Gold Gemini Nanorods, CTAB Free (Wavelength 850 nm) (7440-57-5)	5ml	See page 42

Item #	LPSR Maximum (nm)	Length (nm)	Width (nm)	Aspect Ratio	Color & Form
79-7010	640 - 670	25 - 31	13 - 18	1.7 - 1.9	violet liq.
79-7015	685 - 715	37 - 43	13 - 18	2.4 - 2.8	blue liq.
79-7020	735 - 765	37 - 44	10 - 13	3.4 - 3.7	red-purple liq.
79-7025	785 - 815	40 - 50	10 - 13	3.8 - 4.1	red-orange liq.
79-7030	835 - 865	48 - 55	9 - 12	4.6 - 5.3	maroon-purple liq.

**Concentration:** >30 µg/ml  
**pH:** 5.5 - 7.5  
**Stabilizer:** Amphiphilic Agents  
**Solvent:** Stabilized with amphiphilic agents in conductivity grade water (18.0 MΩ cm<sup>-1</sup>)  
**Optical Density:** 1.0 - 1.2  
**Shelf Life:** 12 months



## KITS - GOLD NANOPARTICLES KIT

**96-1547 Gold Nanoparticles Kit (5nm-40nm diameter, OD 1, stabilized suspension citrate buffer)**  
 Components also available for individual sale.  
 Contains the following:

79-0182	Gold Nanoparticles (5nm, 1 OD, supplied in 0.1mM stabilizing surfactant, 515-520nm abs. max.) (7440-57-5)	25ml	See page 38
79-0210	Gold Nanoparticles (10nm, 1 OD, supplied in 0.1mM stabilizing surfactant, 515-520nm abs. max.) (7440-57-5)	25ml	See page 38
79-0212	Gold Nanoparticles (15nm, 1 OD, supplied in 0.1mM stabilizing surfactant, 520nm abs. max.) (7440-57-5)	25ml	See page 38
79-0214	Gold Nanoparticles (20nm, 1 OD, supplied in 0.1mM stabilizing surfactant, 524nm abs. max.) (7440-57-5)	25ml	See page 38
79-0216	Gold Nanoparticles (30nm, 1 OD, supplied in 0.1mM stabilizing surfactant, 526nm abs. max.) (7440-57-5)	25ml	See page 38
79-0218	Gold Nanoparticles (40nm, 1 OD, supplied in 0.1mM stabilizing surfactant, 530nm abs. max.) (7440-57-5)	25ml	See page 38

## KITS - GOLD NANOPARTICLES KIT (Reactant-Free)

**96-1545 Gold Nanoparticles Kit, Reactant-Free (5nm-40nm diameter, OD 1, suspension in phosphate-buffered saline, 515-530nm abs. max.)**  
Components also available for individual sale.  
Contains the following:

79-0180	Gold Nanoparticles (5 nm diameter, 1 OD, stabilized suspension in phosphate-buffered saline, 515-520 nm abs. max.) reactant free (7440-57-5)	25ml	See page 37
79-0184	Gold Nanoparticles (10nm diameter, 1 OD, stabilized suspension in phosphate-buffered saline, 520nm abs. max.) reactant free (7440-57-5)	25ml	See page 37
79-0186	Gold Nanoparticles (15nm diameter, 1 OD, stabilized suspension in phosphate-buffered saline, 520nm abs. max.) reactant free (7440-57-5)	25ml	See page 37
79-0188	Gold Nanoparticles (20nm diameter, 1 OD, stabilized suspension in phosphate-buffered saline, 524nm abs. max.) reactant free (7440-57-5)	25ml	See page 37
79-0190	Gold Nanoparticles (30nm diameter, 1 OD, stabilized suspension in phosphate-buffered saline, 526nm abs. max.) reactant free (7440-57-5)	25ml	See page 37
79-0192	Gold Nanoparticles (40nm diameter, 1 OD, stabilized suspension in phosphate-buffered saline, 530nm abs. max.) reactant free (7440-57-5)	25ml	See page 37

## KITS - GOLD NANORODS KIT (Axial Diameter-25nm, Wavelength 550-700nm)

**96-1530 Gold Nanorods Kit (Axial Diameter - 25 nm, wavelength 550-700 nm)**  
Components also available for individual sale.  
Contains the following:

79-6000	Gold Nanorods (Axial Diameter - 25 nm) (Wavelength 550 nm) (7440-57-5)	25ml	See page 41
79-6005	Gold Nanorods (Axial Diameter - 25 nm) (Wavelength 600 nm) (7440-57-5)	25ml	See page 41
79-6010	Gold Nanorods (Axial Diameter - 25 nm) (Wavelength 650 nm) (7440-57-5)	25ml	See page 41
79-6015	Gold Nanorods (Axial Diameter - 25 nm) (Wavelength 700 nm) (7440-57-5)	25ml	See page 41

## KITS - GOLD NANORODS KIT (Axial Diameter-10nm, Wavelength 700-808nm)

**96-1535 Gold Nanorods Kit (Axial Diameter - 10 nm, wavelength 700-808 nm)**  
Components also available for individual sale.  
Contains the following:

79-6020	Gold Nanorods (Axial Diameter - 10 nm) (Wavelength 700 nm) (7440-57-5)	25ml	See page 41
79-6025	Gold Nanorods (Axial Diameter - 10 nm) (Wavelength 750 nm) (7440-57-5)	25ml	See page 41
79-6030	Gold Nanorods (Axial Diameter - 10 nm) (Wavelength 780 nm) (7440-57-5)	25ml	See page 41
79-6035	Gold Nanorods (Axial Diameter - 10 nm) (Wavelength 808 nm) (7440-57-5)	25ml	See page 41

## KITS - GOLD NANOSPHERES KIT

**96-1540 Gold Nanospheres Kit (30-90 nm)**  
Components also available for individual sale.  
Contains the following:

79-6040	Spherical Gold Nanoparticles (30 nm) (7440-57-5)	25ml	See page 39
79-6045	Spherical Gold Nanoparticles (50 nm) (7440-57-5)	25ml	See page 39
79-6050	Spherical Gold Nanoparticles (70 nm) (7440-57-5)	25ml	See page 39
79-6055	Spherical Gold Nanoparticles (90 nm) (7440-57-5)	25ml	See page 39

## KITS - GRAPHENE QUANTUM DOTS (GQDs) MASTER KIT

**96-7410 Graphene Quantum Dots (GQDs) Master Kit**  
Sold in collaboration with Dotz Nano Ltd. for research purposes only. Suggested use within 6 months of purchase. Do not freeze. Store in DARK.  
Components also available for individual sale.  
Contains the following:

06-0330	Graphene Quantum Dots (GQDs), Aqua-Green Luminescent (1034343-98-0)	100mg	See page 31
06-0332	Graphene Quantum Dots (GQDs) in water, Aqua-Green Luminescent (1034343-98-0)	100ml	See page 31
06-0334	Graphene Quantum Dots (GQDs), Blue Luminescent (1034343-98-0)	100mg	See page 31
06-0336	Graphene Quantum Dots (GQDs) in water, Blue Luminescent (1034343-98-0)	100ml	See page 31
06-0340	Graphene Quantum Dots (GQDs) in water, Cyan Luminescent (1034343-98-0)	100ml	See page 31

Item #	Photoluminescence			
	QY* *	$\lambda_{\max}$ *	Max emission	FWHM *
<b>06-0330 / 06-0332</b>	>17%	485 nm	525 nm	70 nm
<b>06-0334 / 06-0336</b>	>65%	350 nm	445 nm	65 nm
<b>06-0340</b>	>25%	420 nm	490 nm	80 nm
<b>Abbreviations</b>				
	QY*	Quantum Yield		
	$\lambda_{\max}$	Maximum excitation wavelength		
	FWHM	Full width at half maximum		

## KITS - GRAPHENE QUANTUM DOTS (GQDs) MINI KIT (Powders)

**96-7425 Graphene Quantum Dots (GQDs) Mini Kit (Powders)**  
 Sold in collaboration with Dotz Nano Ltd. for research purposes only. Suggested use within 6 months of purchase. Do not freeze.  
 Store in DARK.  
 Components also available for individual sale.  
 Contains the following:

06-0330	Graphene Quantum Dots (GQDs), Aqua-Green Luminescent (1034343-98-0)	100mg	See page 31
06-0334	Graphene Quantum Dots (GQDs), Blue Luminescent (1034343-98-0)	100mg	See page 31

Item #	Color & Form	Photoluminescence			
		QY* *	$\lambda$ max *	Max emission	FWHM *
06-0330	dark red-brown pwdr.	>17%	485 nm	525 nm	70 nm
06-0334	dark brown pwdr.	>65%	350 nm	445 nm	65 nm
Particle diameter: <5 nm Topographic height: 1.0 - 2.0 nm					
Abbreviations: QY* = Quantum Yield; $\lambda$ max = Maximum excitation wavelength; FWHM = Full width at half maximum					

## KITS - GRAPHENE QUANTUM DOTS (GQDs) MINI KIT (Liquids)

**96-7420 Graphene Quantum Dots in water (GQDs) Mini Kit (Liquids)**  
 Sold in collaboration with Dotz Nano Ltd. for research purposes only. Suggested use within 6 months of purchase. Do not freeze.  
 Store in DARK.  
 Components also available for individual sale.  
 Contains the following:

06-0332	Graphene Quantum Dots (GQDs) in water, Aqua-Green Luminescent (1034343-98-0)	100ml	See page 31
06-0336	Graphene Quantum Dots (GQDs) in water, Blue Luminescent (1034343-98-0)	100ml	See page 31
06-0340	Graphene Quantum Dots (GQDs) in water, Cyan Luminescent (1034343-98-0)	100ml	See page 31

Item #	Color & Form	Photoluminescence			
		QY* *	$\lambda$ max *	Max emission	FWHM *
06-0332	cloudy orange liq.	>17%	485 nm	525 nm	70 nm
06-0336	cloudy colorless liq.	>65%	350 nm	445 nm	65 nm
06-0340	cloudy brown liq.	>25%	420 nm	490 nm	80 nm
Particle diameter: <5 nm Topographic height: 1.0 - 2.0 nm Concentration: 1mg/ml					
Abbreviations: QY* = Quantum Yield; $\lambda$ max = Maximum excitation wavelength; FWHM = Full width at half maximum					



# KITS - HIGH SURFACE AREA SILICA NANOPARTICLES KIT

96-5050

## High Surface Area Silica Nanoparticles Kit

NEW

These products are under license of patented Technology from King Abdullah University of Science and Technology – KAUST. Patent PCT/IB2010/002421.

Components also available for individual sale. Contains the following:

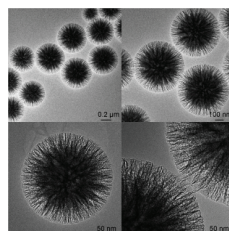
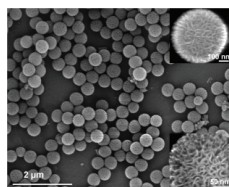
14-6100	High Surface area Silica nanoparticles, large, particle size ~900-1000 nm, surface area ~700 m <sup>2</sup> /g, (KCC-1 L1) (112945-52-5)	1g	See page 52
14-6110	High Surface area Silica nanoparticles, large, particle size ~900-1000 nm, surface area ~600 m <sup>2</sup> /g, (KCC-1 L2) (112945-52-5)	1g	See page 53
14-6120	High Surface area Silica nanoparticles, large, particle size ~900-1000 nm, surface area ~550 m <sup>2</sup> /g (KCC-1 L3) (112945-52-5)	1g	See page 53
14-6200	High Surface area Silica nanoparticles, medium, particle size ~400-450 nm, surface area ~400 m <sup>2</sup> /g, (KCC-1 M1) (112945-52-5)	1g	See page 53
14-6210	High Surface area Silica nanoparticles, medium, particle size ~300-350 nm, surface area ~600 m <sup>2</sup> /g, (KCC-1 M2) (112945-52-5)	1g	See page 53
14-6300	High Surface area Silica nanoparticles, small, particle size ~130-190 nm, surface area ~380 m <sup>2</sup> /g, (KCC-1 S1) (112945-52-5)	1g	See page 53
14-6310	High Surface area Silica nanoparticles, small, particle size ~40-50 nm, surface area ~520 m <sup>2</sup> /g, (KCC-1 S2) (112945-52-5)	250mg	See page 53

### Technical Note:

- Novel fibrous shaped silica nanospheres, denoted as KCC-1 (KAUST Catalysis Center)<sup>[1]</sup>, have unique physical properties which have never before been reported in silica materials. These nanomaterials have been developed by Prof. J. M. Basset of King Abdullah University of Science and Technology (KAUST). A fibrous surface morphology arranged in three-dimensional structure forms the spheres (Fig. 1). Unlike traditional pore-based silica, these nanospheres possess a fibrous structure that increases accessibility to the available surface area; this in turn, significantly increases the catalytic activity.

These materials exhibit excellent physical properties, including a high surface area, a fibrous surface morphology, good thermal and hydrothermal stabilities and high mechanical stability (Table 1). The fibrous morphology of KCC-1 remains unaffected even after mechanical compression up to 216 MPa pressure. This is superior to the conventional MCM-41 type of silica, which is affected at pressure 86 MPa.<sup>[1]</sup>

A range of heterogeneous catalysts, prepared using KCC-1 as a supporting material, have been showing excellent catalytic activity for various transformations of research and industrial importance. As a catalyst support, sorbent or carrier, KCC-1 is able to demonstrate superior activity as compared to regular mesoporous silica materials in energy related processes<sup>[2-3]</sup>, a variety of organic reactions<sup>[4-7]</sup>, biomedical applications and drug delivery systems<sup>[8]</sup>, optoelectronic devices<sup>[9]</sup> and many others.

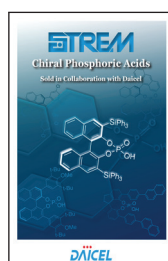
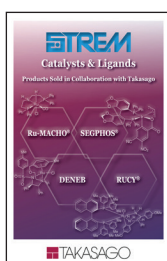
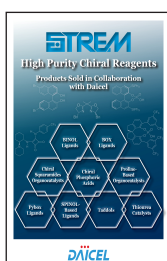
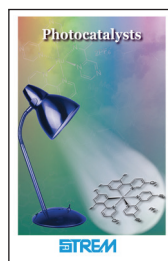
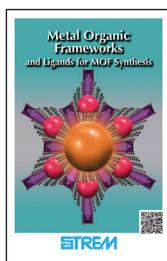
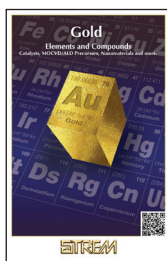
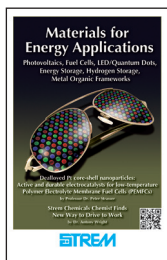
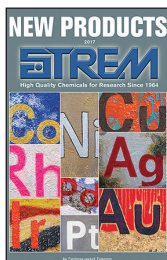
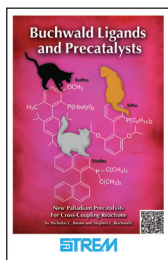
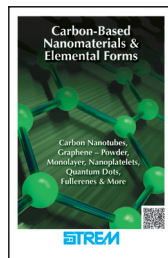
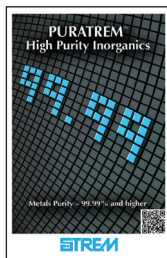
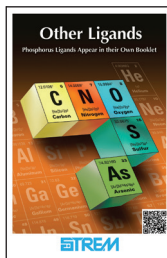
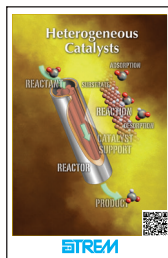
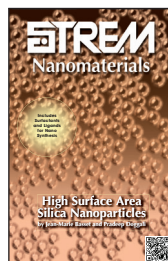
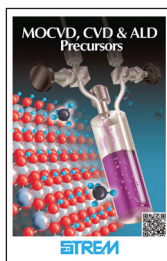
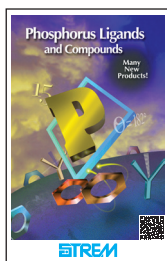
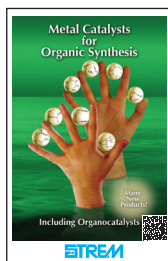


Product #	Category	Grade	Particle Size (nm)	Surface Area (m <sup>2</sup> /g)	Pore Volume (cm <sup>3</sup> /g)
14-6100	Large	(KCC-1 L1)	~900-1000	~700	~1.4
14-6110	Large	(KCC-1 L2)	~900-1000	~600	~1.2
14-6120	Large	(KCC-1 L3)	~900-1000	~550	~0.9
14-6200	Medium	(KCC-1 M1)	~400-450	~400	~0.7
14-6210	Medium	(KCC-1 M2)	~300-350	~600	~0.6
14-6300	Small	(KCC-1 S1)	~130-190	~380	~0.8
14-6310	Small	(KCC-1 S2)	~40-50	~520	~1.3

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