Chemical Synthesis

Strem Nanomaterials for Chemical Synthesis

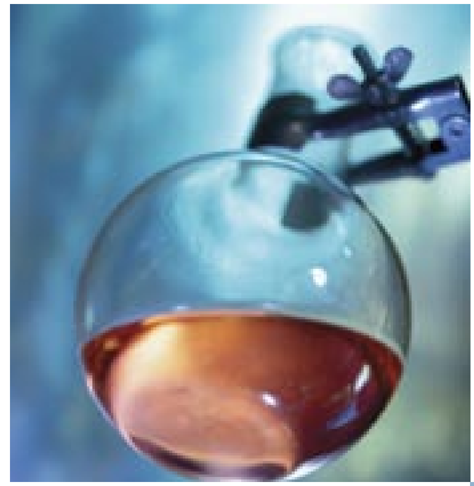
Potential Applications

Catalysis

Separations

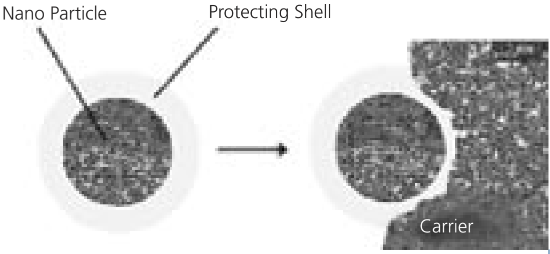
Remediation

Since its inception, Strem Chemicals has focused on offering unique organometallic compounds for both academic and industrial research purposes. Close relationships with leading researchers in the field have enabled Strem to stay abreast of the latest scientific advances in and regularly add novel chemicals to our product portfolio. Most recently Strem has embraced the emerging area of nanotechnology and formed a collaboration with the Max-Planck-Institut fuer Kohlenforschung. A series of nanomaterials, including metal nanoclusters, metal nanocolloids (organosols and hydrosols), metal nanopowders, metal nanoparticles, and magnetic fluids are now available from Strem. Below is a discussion of potential applications of these nanomaterials in the chemicals market sector.



Catalysis

Catalysts play a significant role in the production of chemicals today. Nanomaterials have the potential for improving the efficiency, selectivity, and yield of catalytic processes. The higher surface to volume ratio means that much more of the catalyst is actively participating in the reaction. The potential for cost savings is tremendous from a material, equipment, labor, and time standpoint. Higher selectivities mean less waste and fewer impurities, which could lead to safer drugs and reduced environmental impact.



The precursor concept

Nanoscale catalysts have been investigated in a number of reactions. Nanometal colloids have been of particular interest. In the precursor concept, pre-prepared nanometal colloids can be tailored for special applications independently of the support by modifying them with lipophilic or hydrophilic protective coatings. Adsorption onto the support is achieved by dipping the material into a solution of the particles. Surfactant stabilized nanometal colloid catalysts have been found to surpass conventional catalysts for hydrogenation and oxidation reactions. The first intramolecular Pauson-Khand reaction in water was successfully carried out by using aqueous colloidal cobalt nanoparticles as the catalyst.

Metal nanoclusters have also been found to be good catalysts. Nanoparticles supported on polymers have been found to catalyze hydrogenations and carbon-carbon coupling reactions. Colloids of bi- and tri-metallic nanoclusters have been shown to be active and selective catalysts in the Suzuki cross-coupling, Phauson-Khand, and hydrogenation reactions. Metal clusters retain their activity for extended periods of time and over a range of substrates. Gold nanoclusters have also exhibited catalytic activity for the low temperature oxidation of carbon monoxide, even though bulk gold is inactive.

Metal nanoparticles on a variety of supports have also been investigated as catalysts. Zinc and platinum nanoparticles supported on a zeolite matrix exhibited high aromatizing activity in the conversion of lower alkanes. Nanoscale cobalt particles dispersed in charcoal were used as catalyst for the Pauson-Khand, reductive Pauson-Khand, and hydrogenation reactions.

Other types of nanocatalysts have been studied as well. Nanopowder catalysts composed of silica and platinum nanoparticles exhibited very strong catalytic activity for hydrolyzation reactions. Intra-dendrimer hydrogenation and carbon-carbon coupling reactions took place in a variety of solvents (water, organics, biphasics, supercritical CO_2) using dendrimer-encapsulated metal nanoparticles.

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STREM CHEMICALS, INC.

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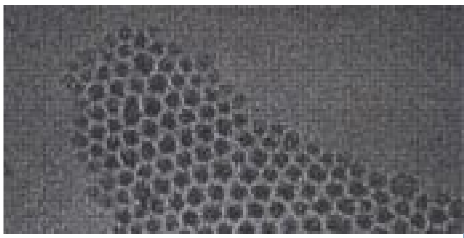
Strem Nanomaterials for Chemical Synthesis

Separations

Separation of desired product from unwanted impurities and contaminants can often be a challenge. Nanomaterials, in the form of magnetic nanoparticles, may help resolve many separations problems.



TEM of air stable 10nm Co particles

Magnetic fluids are colloidal dispersions of surface coated magnetic nanoparticles. They are attractive in separation applications because the reactivity of the particles can be tailored by modifying the surface coatings on the nanoparticles. The nanoscale particles afford very high surface areas without the use of porous absorbents and can be recovered for reuse. Magnetic fluids are being investigated for a number of different chemical separations applications.

Nanocatalysts containing magnetic nanoparticles are being developed. Silica and carbon are utilized to maintain the stability of the nanoparticles under reaction conditions. Functionalized surfaces on the nanoparticles include immobilizing sites for catalytically active species such as nanometal particles, enzymes, and homogenous catalysts. The catalysts are easily separated by utilizing the magnetic interaction between the magnetic nanoparticle and an external applied magnetic field. These hybrid catalysts offer the advantages of homogeneous and heterogeneous catalysis combined.

In biochemical reactions, magnetic nanoparticles are being investigated as a means to aid in the separation and recovery of target biomolecules such as DNA, RNA, and proteins. The separation of organic contaminants such as polyaromatic hydrocarbons from water and the removal of sulfur compounds from hydrocarbon fuels are also being investigated with magnetic fluids.

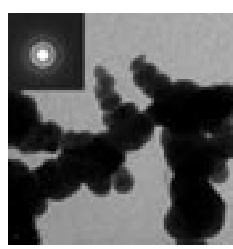
Remediation

Despite large and ongoing efforts to reclaim sites contaminated by toxic chemicals, many locations remain difficult to address due to the location of the contamination. Nanomaterials are being investigated as potential agents for the destruction of toxins and may enable remediation in some challenging scenarios.

Nano-scale zero-valent iron (NZVI) has been shown to cause the rapid destruction of a wide range of contaminants (perchlorate, hexavalent chromium, and numerous chlorinated organic compounds) via a surface catalyzed redox process. Effectiveness of NZVI has been demonstrated in the lab and in the field on a pilot scale in contaminated soils, sediments, groundwater, and wastewater. Potential cost savings are tremendous as the remediation can take place without pumping the contaminated water to the surface for treatment. It may also be possible to remediate very deep plumes of contaminated groundwater by placing nanoparticles into the sub-surface via deep well injection.

Nanoparticles of gold and palladium have been found to be highly effective catalysts for the remediation of trichloroethylene (TCE) in groundwater. The nanoparticles provide the maximum number of palladium atoms for interaction with the TCE molecules and greatly improve the efficiency of the process several orders of magnitude over bulk palladium catalysts. As with iron nanoparticles, in-situ decontamination could add additional cost savings.

A listing of specific metal nanoclusters, metal nanocolloids (organosols and hydrosols), metal nanopowders, metal nanoparticles, and magnetic fluids offered by Strem is available upon request or via our website. Application sheets discussing the potential use of these products in the medical and pharmaceutical, defense and security, chemical, automotive, and energy fields, and as magnetic fluids, can also be obtained from Strem. More information is also available in the form of a reference sheet listing literature source materials.



TEM of Nano iron particle clusters. Reprinted with permission from Environmental Science and Technology 39 (2005) 1221-30. Copyright ACS 2005. Photo C. Wang, courtesy Pacific Northwest National Laboratory

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