Gold AURO*lite*™ Nanoparticle Catalysts

Sold in collaboration with Project AuTEK

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Catalog Number and Name	79-0160 Gold 1% on aluminum oxide extrudates (AURO*lite*™ Au/Al_2O_3)	79-0165 Gold 1% on titanium dioxide extrudates (AURO*lite*™ Au/TiO_2)	79-0170 Gold 1% on zinc oxide granulate (AURO*lite*™ Au/ZnO)
Color and Form	dark purple extrudates ~1.2mm dia. x 5mm (avg)	dark purple/gray extrudates 1.5mm dia. x 5mm (avg)	dark purple granulate 1-2mm dia.
Analysis	Au 1 wt% ± 0.1% Al_2O_3 98 wt% Na^+, Cl^- <1500ppm	Au 1 wt% ± 0.1% TiO_2 98 wt% Na^+, Cl^- <1500ppm	Au 1 wt% ± 0.1% ZnO 88 wt% (contains Al_2O_3) Na^+, Cl^- <1500ppm
Other	Bulk density: 0.6–0.8 g/ml Specific surface area: 200-260 m^2/g *(store cold)*	Bulk density: 0.85–0.95 g/ml BET (surface area): 40-50 m^2/g *(store cold)*	Bulk density: 1-1.2 g/ml BET (surface area): 40-50 m^2/g *(store cold)* Note: PCT WO2005115612
Available sizes: 10g, 50g			

Sold in collaboration with Project AuTEK for research purposes. Reverse engineering and product modification prohibited.

Only open before use, store cold in dark.

Technical Note:

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

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.

"Please note: every care has been taken when producing the gold catalysts and their data sheets, however, users of the catalysts are advised that Mintek and its partners in Project AuTEK bear no responsibility for the performance of the catalysts or any accident, injury, death and / or damage arising from their delivery, handling or use."

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Capabilities of AURO*lite*™ Catalysts

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AURO*lite*™ catalysts (1wt%gold on titania, alumina and zinc oxide supports) are made in kilogram quantities by Project AuTEK and their advantages over other precious metal catalysts are being demonstrated by achieving high activities and selectivities in both liquid- and gas-phase reactions which have commercial potential.

1. Introduction

Gold catalysts are very active under the mild conditions which favour their selectivity and the economics of the processes involved. Careful choice of preparative conditions and supports helps to maximize their selectivity and activity [1]. Their potential in chemical processing reactions has been clearly demonstrated and there is definite evidence of increasing R&D involving gold and gold-platinum group metal (PGM) combinations [2]. This is likely to result in new industrial applications for gold catalysts in chemical processing and pollution control. Selective oxidation of carbon monoxide in the hydrogen streams used for fuel cells has been achieved using AuTEK catalysts, as is the use of this ambient temperature oxidation process for use in gas masks for protection from CO poisoning and for CO removal from room atmospheres [2,3]. AuTEK has produced three gold catalyst systems, and use of these catalysts, and other closely related gold catalysts to optimize requirements for particular reactions where high activity or selectivity to desirable products is required, is indicated below.

2. Gas Phase Reactions

AURO*lite*™ catalysts have been evaluated for their CO oxidation characteristics at Oak Ridge National Laboratories, USA [4]. The Au/TiO_2 catalyst gave 100% conversion of CO at < O °C and the Au/Al_2O_3 catalyst was also very active at low temperatures. All three AURO*lite*™ catalysts are being developed by Project AuTEK for CO oxidation in respiratory protection devices [5]. As can be seen in Figure 1, under typical EN403 (fire escape mask) test conditions the Au/TiO_2 is more active and durable than the established commercial technology namely Hopcalite (CuMnOx). Furthermore under these conditions the activity of this material is amplified by the presence of moisture, unlike Hopcalite which experiences rapid deactivation.

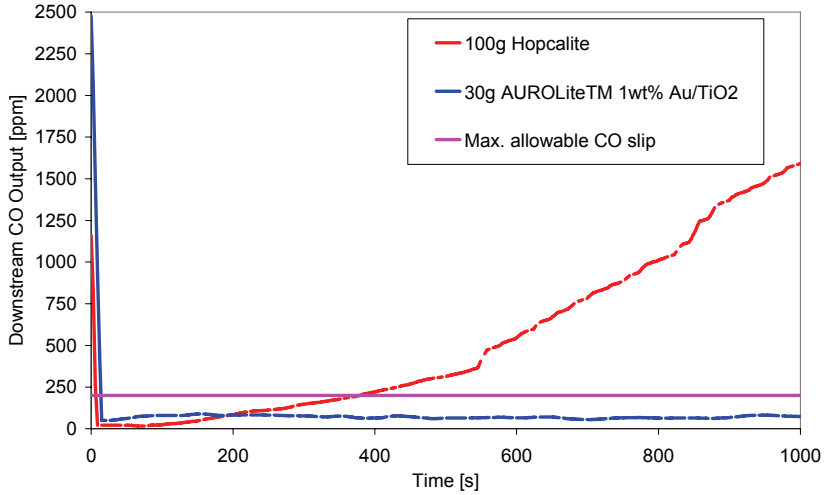

Figure 1 : EN403 Simulation, feed = 2500ppm CO in air, 90%RH, 30LPM, constant flow, bed = 4.7cm diameter, particle size 1 - 2mm.

The AURO*lite*™ Au/TiO_2 catalyst has been used for the oxidation of CO and H_2 by O_2 and N_2O by a group from the Technical University of Denmark, Lyngby [6]. This group also studied the low temperature oxidation of methane on AURO*lite*™ catalysts and found them active and stable with very little sintering up to 250°C [7]. The catalysts have also been shown to give complete conversion of propene at 250 – 350°C (i.e. VOC removal) and the gold particles do not sinter under these conditions either [8]. The alumina and zinc oxide catalysts give high conversions in methanol oxidation [9]. In addition, all three catalysts are currently being assessed for water-gas shift and selective hydrogenation activity.

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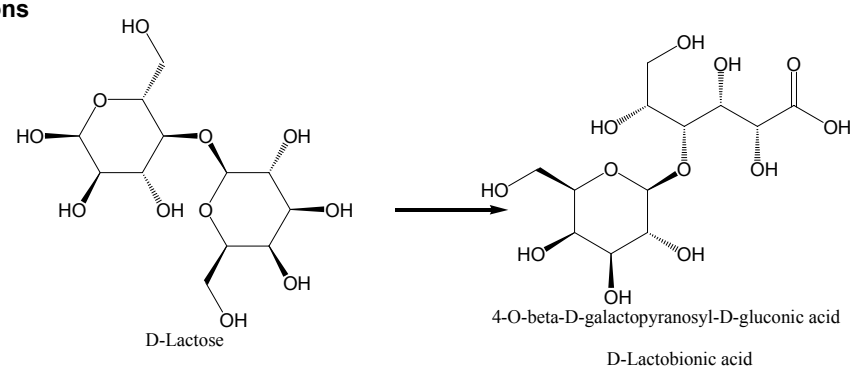
Gas phase selectivity of gold catalysts has been confirmed in an unconventional PROX system, where the complete removal of CO from 'dirty' hydrogen (i.e. down to < 1ppm CO from up to 2000 ppm). For use in a fuel cell, the carbon monoxide still present in the hydrogen, obtained by water-gas shift or from other sources, must be removed to prevent it poisoning the platinum electro-catalyst inside the fuel cell. Gold catalysts have been found to be effective for this preferential oxidation reaction. Whereas PGM catalysts oxidize both the CO and the hydrogen, gold is selective for CO at close to ambient temperatures. This has enabled Project AuTEK to develop a new system for hydrogen purification for PEM fuel cells, trade named AURO*PureH*$_2$™ based on the use of a 3wt%Au/TiO_2 catalyst used at room temperature [10].

3. Liquid Phase Reactions



Following their successful use in the oxidation of glucose to gluconic acid, the conversion of D-lactose to D-lactobionic acid (LBA) has been studied using Project AuTEK catalysts.

Results obtained using samples of the three AuTEK gold catalysts show that all of these materials produce high selectivity for LBA under mild conditions [11]. It has been found, however, that the activities vary with support type, with the 1wt%Au/ZnO catalyst being the most reactive, as indicated in Table 1:

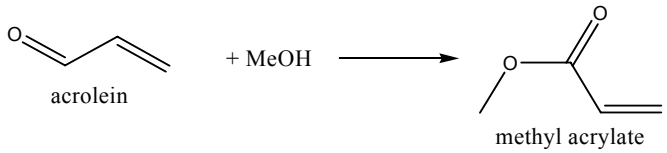
Table 1 : Support effects in the oxidation of D-lactose to D-lactobionic acid

	0.8%Au/Al_2O_3	1%Au/TiO_2	1%Au/ZnO
M x $t_{20\%}$* (g_{Au}min)	9.12	7.4	5.6
Selectivity (%)	94.3	95.1	93.9

C_0=99.6 mmol l^{-1}, 0.2 g_{cat}, T = 60 °C, pH=8, O_2=2.5ml min^{-1}, results adapted from ref 11.

*time in minutes to reach 20% conversion

AuTEK catalysts have also been used to catalyse the aerobic oxidation of aldehydes to esters, e.g. the conversion of acrolein to methyl acrylate [12]:



Methyl acrylate is used in the manufacture of paints, in solvents and for acrylate coatings. This reaction proceeds in methanol using air as oxidant at room temperature, and therefore has the appeal of being 'green' chemistry. The high conversions and selectivities are indicated in Table 2.

Table 2 : Synthesis of methyl acrylate from acrolein using 1wt%Au/TiO_2 AuTEK catalyst

Time (h)	1	4	20
Conversion (%)	46	75	97
Selectivity (%)	43	66	87

Acrolein:Methanol 1:80, 0.3 mol % 1wt %Au/TiO_2, T = 25°C, results adapted from ref 12.

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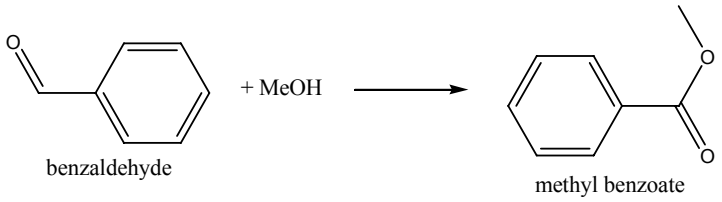
In addition, the use of AuTEK catalysts has been studied for the reaction between benzaldehyde and methanol to produce methyl benzoate [12], which has a pleasant odour and is used in perfumes. 100% conversion was obtained in ca. 20 min when the benzoic acid:methanol ratio was 1:30 in the presence of 0.2 mol% 1wt%Au/TiO_2 AuTEK catalyst and 10mol% NaOMe at 40°C:



Other reaction types for which AURO*lite*™ catalysts are being investigated include glucose and glycerol oxidation, direct hydrogen peroxide synthesis and hydrodechlorination of water contaminants such as trichloroethene.

4. Conclusions

Gold catalysts are likely to make a large and unique contribution to applications where efficient chemical processes of the kind described herein are required under mild energy-efficient conditions, as is adequately indicated by the examples obtained using AuTEK catalysts and related work described in recent literature.

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