ISGC 2019 May 13rd - 17th

N°448 / OC
TOPIC(s) : Biomass conversion / Industrial chemistry

OXIDATION OF GLUCOSE TO GLUCARIC ACID USING SUPPORTED GOLD CATALYSTS

AUTHORS

Eleonora MONTI / DEPARTMENT OF INDUSTRIAL CHEMISTRY "TOSO MONTANARI, VIALE RISORGIMENTO 4, BOLOGNA
Stefania SOLMI / DEPARTMENT OF INDUSTRIAL CHEMISTRY "TOSO MONTANARI, VIALE RISORGIMENTO 4, BOLOGNA
Tommaso TABANELLI / DEPARTMENT OF INDUSTRIAL CHEMISTRY "TOSO MONTANARI, VIALE RISORGIMENTO 4, BOLOGNA
Calogero MORREALE / DEPARTMENT OF INDUSTRIAL CHEMISTRY "TOSO MONTANARI, VIALE RISORGIMENTO 4, BOLOGNA
Fabrizio CAVANI / DEPARTMENT OF INDUSTRIAL CHEMISTRY "TOSO MONTANARI, VIALE RISORGIMENTO 4, BOLOGNA
Nikolaos DIMITRATOS / DEPARTMENT OF INDUSTRIAL CHEMISTRY "TOSO MONTANARI, VIALE RISORGIMENTO 4, BOLOGNA

PURPOSE OF THE ABSTRACT

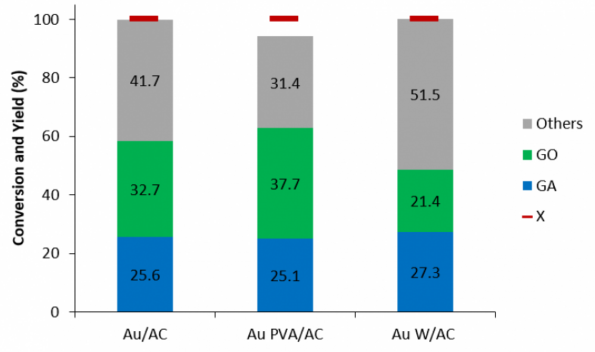
Glucaric acid (GA) is one of the building blocks derived from sugar biomass with higher added value and better perspective for future exploitation.1 GA can be synthesized by oxidation of D-Glucose (Glu) and it can be employed for many uses; for instance, it is a precursor of adipic acid, a monomer for Nylon-6,6 2. Nowadays, GA can be produced by oxidation of D-Glucose with either stoichiometric oxidants, or by means of electrochemical or biochemical synthesis. However, these processes show drawbacks from either the environmental or the economic viewpoint.3 Therefore, the study of a more sustainable process to produce GA from D-Glucose is of great scientific and practical interest using supported metal nanoparticles.

We investigated the oxidation of D-Glucose in aqueous solvent with molecular oxygen, and solid catalysts based on supported tailored Au nanoparticles (NPs) with specific preformed particle size using colloidal methods. We prepared mono metallic NPs supported on a range of supports (activated carbon and other metal oxides with nominal metal loading of 1 % wt to study the influence of acid/base properties and metal-support interaction. The catalytic performance of the synthesized materials in terms of activity, yield was evaluated in a batch autoclave reactor. A systematic study was carried out to investigate the effect of different reaction parameters (temperature, glucose concentration, reagent molar ratio).

At first it has been studied how the nanoparticles size can affect the reaction behavior, preparing Au NPs with three different methods: Au/AC, AuPVA/AC and AuW/AC. The effect of Au particle size was evaluated in terms of activity and yield and the experimental data showed that with Au particle size of 4.1nm the undesired Gluconic acid (GO) degradation to lighter carboxylic acids prevailed over its selective oxidation to GA.4 These results are shown in Figure 1; GA yield was slightly increased from 25% to 27% with the decrease of Au nanoparticles dimension, and the yield to Other products was 51%.

Indeed, the catalytic tests using a range of supports (inert and reducible) suggest that metal-support interaction, influence of particle size, metal dispersion, porosity and nature of ligand have a strong influence in the activity and yield to the desired product. The best catalytic performance was shown by the carbon-supported Au catalyst, showing the greater surface area and average NP size close to 4 nm. With this latest catalytic system, we obtain the complete conversion of glucose and a GA yield of 31% (Figure 2). Structure-activity relationships will be presented and discussed emphasizing on the role of Au particle size and support.

FIGURES

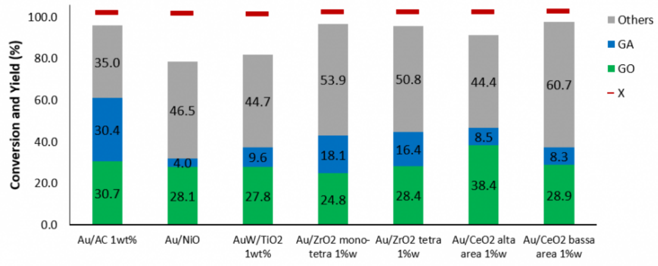


Mean particle size [nm]	12.9	7.3	4.1

Figure 2: Catalytic results obtained supporting Au/AC prepared with different method;

Condition: Sol Glu 5%wt, Glu:Au:NaOH=500:1:1500, PO_2 = 10bar, T=60°C, t=3h;

Table1: mean particle size was determined by TEM analysis.



A sup [m²/g]	956	210	90	82	165	224	60
Mean particle size [nm]	4.1	3.6		5.0	3.8	8.0	2.8

Figure3: Catalytic results obtained supporting Au over different materials;

Condition: Sol Glu 5%wt, Glu:Au:NaOH=500:1:1500, PO_2 = 10bar, T=60°C, t=3h;

Table2: Support surface area and metal nanoparticles size values (B.E.T and TEM analysis)

FIGURE 1

Figure1

Catalytic results obtained supporting Au/AC prepared with different method;

Condition: Sol Glu 5%wt, Glu:Au:NaOH=500:1:1500, PO2 = 10bar, T=60°C, t=3h;

Mean particle size was determined by TEM analysis.

FIGURE 2

Figure2

Catalytic results obtained supporting Au over different materials;

Condition: Sol Glu 5%wt, Glu:Au:NaOH=500:1:1500, PO2 = 10bar, T=60°C, t=3h;

Support surface area and metal nanoparticles size values (B.E.T and TEM analysis)

KEYWORDS

Glucose oxidation | Glucaric acid | Gold | Nanoparticles

BIBLIOGRAPHY

1. T. Werpy, G. Petersen: Top Value Added Chemicals from Biomass; US Department of Energy, Washington DC, 2004
2. University of York: Polyamides; The Essential Chemical Industry Online, 2013
3. H. Roper: Starch/Starke, 1990, 42, 346
4. S. Solmi, C. Morreale, F. Ospitali, S. Agnoli, F. Cavani; ChemCatChem, 2017, 9, 2797 –2806