Materials Science and Engineering C 71 (2017) 1216–1230

Contents lists available at ScienceDirect

Materials Science and Engineering C

journal homepage: www.elsevier.com/locate/msec

Review

Revolution from monometallic to trimetallic nanoparticle composites, various synthesis methods and their applications: A review

Gaurav Sharma [a,*], Deepak Kumar [a], Amit Kumar [a], Ala'a H. Al-Muhtaseb [b], Deepak Pathania [a], Mu. Naushad [c,*], Genene Tessema Mola [d]

[a] School of Chemistry, Shoolini University, Solan 173212, Himachal Pradesh, India
[b] Department of Petroleum and Chemical Engineering, Faculty of Engineering, Sultan Qaboos University, Muscat, Oman
[c] Department of Chemistry, College of Science, Bld#5, King Saud University, Riyadh, Saudi Arabia
[d] School of Chemistry & Physics, University of KwaZulu-Natal, Pietermaritzburg Campus, Private Bag X01, Scottsville 3209, South Africa

ARTICLE INFO

Article history:
Received 22 May 2016
Received in revised form 18 September 2016
Accepted 2 November 2016
Available online 5 November 2016

Keywords:
Nanoparticles
Monometallics
Trimetallics
Nanocomposites
Graphene
Catalysts

ABSTRACT

Trimetallic nanoparticles are mainly formed by the combination of three different metals. The trimetallic catalysts were considerably more professional than bimetallic one. The trimetallic and bimetallic nanoparticles are of enormous attention than that of monometallic in both technological and scientific view as in these nanoparticles the catalytic properties can be tailored better than that of in the single monometallic catalyst. The trimetallic nanoparticles have been synthesized by different methods such as microwave, selective catalytic reduction, micro-emulsion, co-precipitation and hydrothermal etc. The surfaces area of trimetallic nanoparticles is comparatively unstable and thus gets simply precipitated away from their solution and ultimately resulted in their reduced catalytic activity. By using stabilizers like block copolymers, organic ligands, surfactants and dendrimers the trimetallic nanoparticles can be stabilized. The nanocomposites of trimetallics have been synthesized with inorganic and organic compounds such as: carbon, graphene, gelatin, cellulose, starch, chitosan, alginate, collagen and Al_2O_3 etc. Trimetallic nanoparticles are used as a catalyst due to their outstanding electrochemical catalytic activity in comparison with the monometallic or bimetallic nanoparticles.

Contents

* Corresponding authors.
E-mail addresses: gaurav8777@gmail.com (G. Sharma), shad123@gmail.com (M. Naushad).

http://dx.doi.org/10.1016/j.msec.2016.11.002
0928-4931/

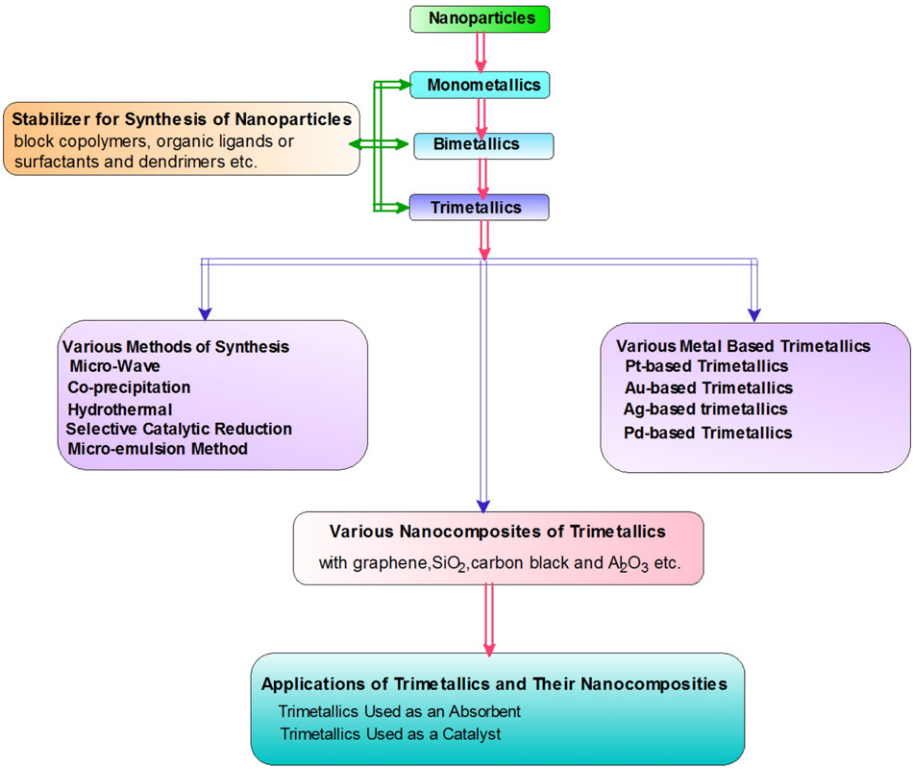
1. Introduction

1.1. General introduction on nanoparticles

The nanoparticles (NPs) may be defined as a distinctive nano-object where all the three Cartesian dimensions are less than 100 nm. These are larger than atoms or molecules individually but smaller than bulk solids. The physical and chemical properties of nano-scaled particles and bulk material are different [1,2]. Another name used for NPs is nanoclusters and "soft" bio-organic nanoparticles. A nanocluster is combination of the same sized particles which are of nanometer dimensions. The nanoparticles (NPs) and nano metal clusters exhibit an important state of condensed matter. However nanoparticles show a gap between the atomic or molecular structure and bulk materials. They show a number of special properties such as high surface area to volume ratio which gives outstanding force for diffusion etc. The nanoparticles find new applications in different fields such as non-linear optics, battery cathodes and ionics, sensors, nano-wires and other systems. As electronic display system has been improved by the metal nanoparticles, which takes the most important position in information technology. The metallic nanoparticles are of different sizes and these are synthesized by chemical approach and their surfaces are stabilized by special functional groups. They are found to be very significant in many fields such as semiconductors [3], electro-optic materials [4], magnetic materials [5–7], catalysis [8–11] and drug delivery system [12,13], removal of organic pollutants [14–16], antimicrobial activity [17–19] and removal of toxic metal ions etc. [20–22]. Scheme-1 represents the revolution from monometallic to trimetallic nanoparticle composites, their various synthesis methods and applications.

1.2. Monometallics to trimetallics

From the monometallics, the physical mixture of nanoparticles likes Ru—Pt in solution shows more catalytic movement than the equivalent monometallic nanoparticles. From single or simple monoatomic catalysts the designable history of catalytic material show an improvement specially Pd, Pt and Au which is in nano dimensioned to bimetallic structure. It has been seen that physical mixture of Ag, Pd, Rh, and Pt, rapidly forms the bimetallic nanoparticles with Au-core structure in aqueous solution. The main reason for using Ag and Rh nanoparticles is the prominent individuality of Rh nanoparticles as a catalyst. On the other hand, the probable electronic effect of silver is similar to gold upon improvement of the catalytic movement with Rhodium. In addition, Ag is cheap metal compared with Au. The colloidal dispersions of Ag and Rh metallic nanoparticles were protected by (PVP) poly (*N*-vinyl-2-pyrrolidone). The polymers which are water soluble were synthesized by an alcohol reduction method. The average diameters of Rh and Ag monometallic nanoparticles were 2.2 nm and 7.5 nm. The catalytic movement



Scheme 1. Representation of revolution from monometallic to trimetallic nanoparticle composites, various synthesis methods and applications.