Open Access Research Journal of
Engineering and Technology
Journals home page: https://oarjpublication/journals/oarjet/
ISSN: 2783-0128 (Online)

OARJ OPEN ACCESS RESEARCH JOURNALS

(RESEARCH ARTICLE)

Check for updates

Synthesis of nanomaterials: Controlling of experimental Conditions

Aseel M. Ajobree [1], Zena M. Jassem [2], Israa M. Radhi [3], Samira A. Mammadova [4], Kalid T. Abdullah [5], Ahmed H. Al-Shami [6], Ahmed A. Ismail [5],Tariq H Al Mgheer [7], Ahmed M. Abass [3], Firas H. Abdulrazzak [8,*], Ayad F. Alkaim [1], Takialdin A. Himdan [9] and Falah H. Hussein [10]

[1] *Department of Chemistry, College of Science for Women, University of Babylon. Babylon.*
[2] *Wheat safety storage and OTAs toxify-Iraq.*
[3] *Department of Chemistry, College of Education for Pure Science, Ibn Al-Haytham, University of Baghdad. Iraq*
[4] *Institute of Physics, Azerbaijan National Academy of Sciences, Azerbaijan.*
[5] *Department of Chemistry, College of education for pure science, University of Diyala, Iraq.*
[6] *Physics Department, Istanbul University of Technology and Science, Turkish.*
[7] *College of Medicine, University of Babylon, Iraq.*
[8] *Forensic Evidence department, College of Science, University of Karkh-Iraq.*
[9] *AL-Esraa University college, Iraq.*
[10] *Department of Pharmaceutics, College of Pharmacy, University of Babylon, Hilla, Iraq.*

Open Access Research Journal of Engineering and Technology, 2023, 04(01), 008–012

Publication history: Received on 28 January 2023; revised on 22 March 2023; accepted on 25 March 2023

Article DOI: https://doi.org/10.53022/oarjet.2023.4.1.0053

Abstract

Numerous studies reported '' how nanomaterials (NMs) can be prepared'.' However, in this work, we are trying to explain some ideas about ''the best route and mechanism for synthesizing ideal size and shape for maximum benefit of applications''. The strategy of synthesizing of nanomaterials with different dimensions by highlighting on the supposed mechanism that could be helps to select the best conditions for the preparations of nanomaterials will be explained. The content also deals with perfect conditions for maximum ideal structure to the great physio-chemical properties and minimum disadvantage which may reduce the activity. Keeping in mind the experimental behavior that could be enhance the activity of synthesis different types of nanomaterials.

Keywords: Nanomaterials; Mechanism; Nuclei; Controlled synthesizing process

1. Introduction

Nanomaterials NMs are achieving extraordinary jump for use in most if not all of nanotechnology applications, due to specific physio-chemical behavior such stability, sensitivity with selectivity of functionalization, optical and electrical properties. We reported in our previous works, about the preparation of NMs [1-2] purification [3], characterization [4] and applications [5] of different types of NMs. This review is focusing on the size control and shape of synthesized NMs which influence directly on charge distribution and ratios of active site for maximum applications ability. NMs may shows filament or crystal pyramidal and cubic, which variance in activity and applications.

2. Strategy of synthesis NMs

NMs could be produced by physical techniques PHTs such sputtering method and mechanical milling or by chemical techniques CHTs such pyrolysis and chemical vapor deposition with specific conditions for every method. Satyanarayana and Reddy reported that The PHTs mostly produce larger particle size with less ability to control that as compare with CHTs and that can relate to manner of synthesis which may top- bottom or inverse respectively [6].

* Corresponding author: Firas H Abdulrazzak

The best technique for synthesizing NMs can be done by CHTs when they built from the center point than growth the skeleton of NMs which can be controlled by change the conditions of growth [7]. Rafael et al. refers to the process of synthesis NMs with CHTs by depend on create nuclei species with favorable properties such homogenous size, ratios of nuclei in solution, nature and volume of solution, charge surface of nuclei, and temperature of precipitations [8]. All of the previous parameters influence on the rate of nucleation then rate of precipitation.

3. Nuclei for built NMs and thermodynamics

In the context of synthesis macro materials MMs, the process required reduce the number of nuclei in solution to prevent the forming colloidal solution, mostly adsorbed many byproduct species and reduce the criticality of product [9]. The process needed for increase the concentration and radius of nuclei until reach to critical value which responsible to growth atoms or molecules and forming OD-NM then increase to 1D, 2D, and 3D-NMs and that depended with noble-metal [8]. After reaching for critical value of concentration and radius nuclei at specific time there is no more of nuclei would be forming only growth would be accrued [10].

The driving forces to forming nuclei and growth to 0D-NMs then orientations the molecules to build layer by layer in growth steps for 1D-NMs or continues to 2D-NMs and 3D-NMs can be related to Gibbs free energy ΔG in equation 1 [11] using an Arrhenius equation.

$$\frac{dN}{dt} = A\exp\left(\Delta G/(k_B\ T)\right) = A\ exp\left(\frac{16\pi\gamma^3\ v^2}{3\ k_B^3\ T^2\ (\ln S)^2}\right) \quad \ldots\ldots\ldots \qquad (1)$$

where dN/dt refers to rate of nucleation N particles during t time, at T temperature and A is a pre-exponential factor. The second part of equation include more details, when reach solution for supersaturation S state, with molar volume v, and the surface energy γ which influence with charge distribution on the nuclei surface. The critical value of radius r_{crti} influence directly with the value of Gibbs free energy as reported in equation 2 by Nguyen et al. [11]:

$$\Delta G_{crti} = \frac{4}{3}\ \pi\gamma r_{crti}^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (2)$$

The important of r_{crti} corresponds to limitation between precipitation NMs and re-dissolved nuclei in solution, thus it taken minimum size to accumulations atoms or molecules layer by layer to forming nano-particles NPs.

4. Stages of growth of NMs

Jitendra *et al.* [12] reported that the process of growth includes several stages every stage characterized by specific dimensions which start from zero-dimensional (0D) to three-dimensional (3D) in addition to two stages are centered one dimensional (1D) and two-dimensional (2D) respectively . The growth prefers to producing homogenous nuclei and that allowed to starting and ending the growth in the same times to achieving uniform size and structure, which is favorable in most applications [11].

Figure 1, shows the process of growth when began with nuclei at 0D then 1D, to 2D and finally to 3D which decided the size, figure, charge distribution and surface area and that agree with many literatures [3-12]. The Roadmap for synthesis NMs by CHTs can be one when take care in the conditions of preparations which can produce 0D -NMs from bulk or 3D-NMs or 3D-NMs from 0D-NMs while that include many limitations with PHTs. The precipitation of NMs were accrued spontaneously when the atomic concentration exceeds the supersaturation state causing the second stage in figure 1 which represent by growth.

Liane et al. reported that controlling the shape of a metal nanoparticle provides an effective strategy to control their catalytic properties which can be succeed in most of applications that required using it. The control did not limit to size but also the degree of crystal when prevent or at least reduce the amorphous structures [13] which mostly reduce the activity of crystal NPs. formation NPs after reach the supersaturation/ nuclei species required three steps Generation nuclei, Diffusion the nuclei to college different species for growth which required the third steps Adsorption [12] between each ether all of it calculate in equation 3, by diffusion Fick's first law.

$$J = [4\pi\ Dr\ (r+\delta)]\ /\ \delta\ *\ (Cb - Ci) \quad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (3)$$

where the distance δ from the particle surface to the bulk concentration Cb of monomers within solution, and Ci refer to the concentration of monomers at the solid/ liquid interface, while Cr is the solubility of the particle. Thus, increase

of nuclear radius with existence of time for growth responsible to decide the critical radius, while diffusion-controlled decided uniformly size of NPs.

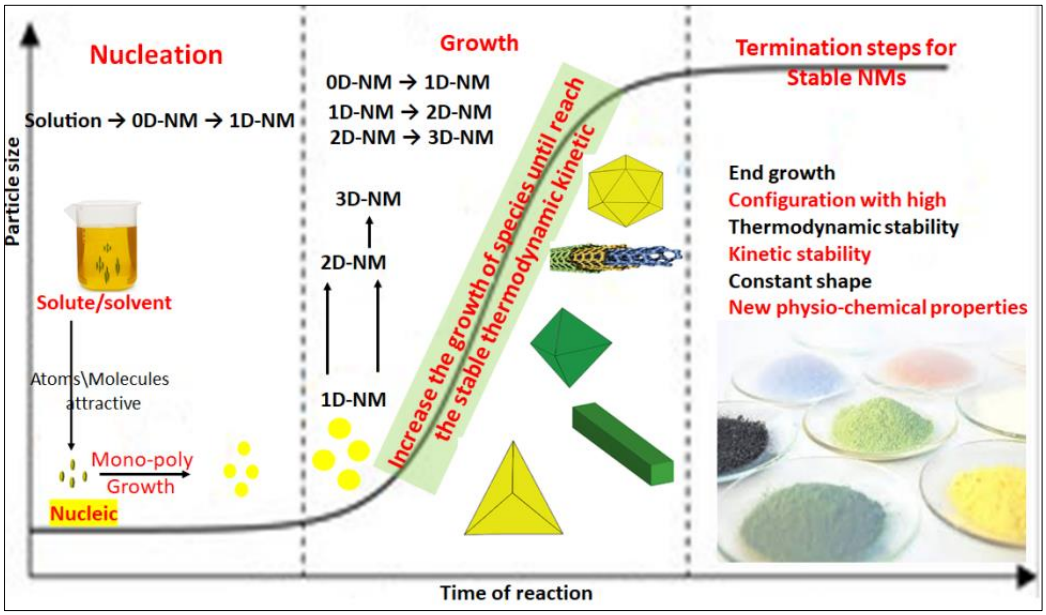

Figure 1 Mechanism of forming NMs in three steps

The Growth by active surface [14] include two mechanisms: Mono-nuclear growth, MNGs which depend on the surface area, and the growth accrued by complete layer before bullied the second layer with taken sufficient time for the growth and diffuse on the active surface. The ether mechanism was poly-nuclear growth, PNGs and that accrued with high concentration which is absolutely no way fast precipitation for second layer to growth before complete growth for first layer. The most important different between MNGs and PNGs is particle size and homogenous precipitations with less agglomeration [15].

5. Experimental conditions for control size of NMs

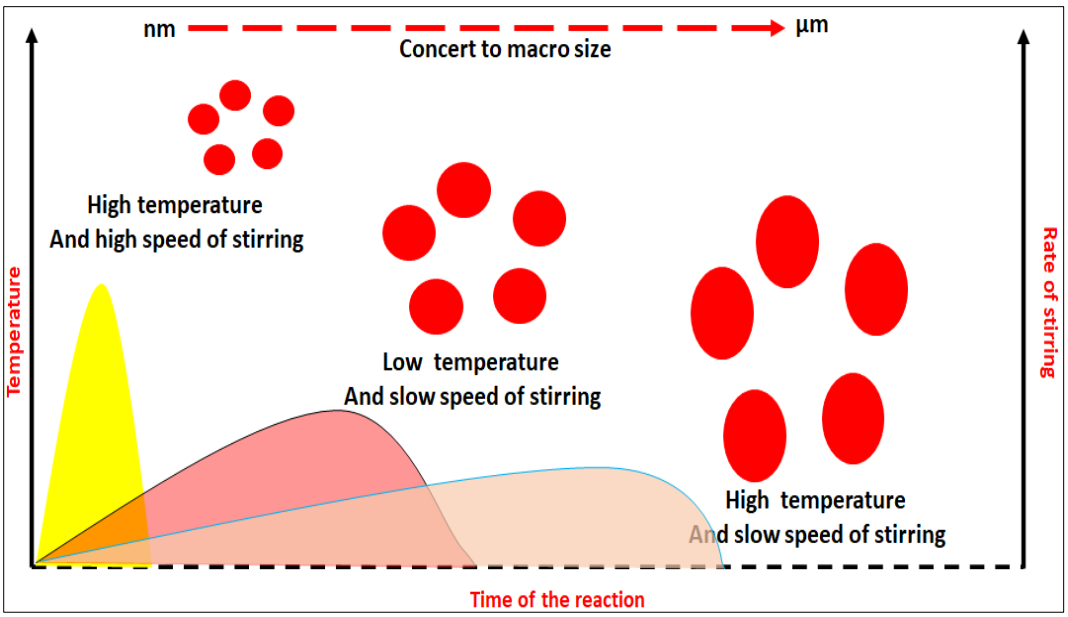

Figure 2 The relationship between temperature and stirring speed with particle size of NMs

Sarah *et al.* [16] reported that heating and speed of stirring play important roles in reduce the size of NMs. Figure 2, shows that high temperature and high seed of stirring succeed to produces less volume of NMs while reduce heating or stirring causing increase the size of precipitation and enhance the agglomerations until reach to micro-size. The experimental condition can be applying by using many instruments such as stirring by magnetic stirrer or ultra-sonic water bath and any appeases that can be prevent the aggregates during precipitation. Sometimes the good choices of concentrations for materials and precipitations reagent can play important roles towards easiest forming of NMs.

6. Conclusion

Nanomaterials NMs are used in huge applications for industrial, biomedical, and electronic and environmental applications. However, all of strategies of synthesizing these materials seeking for quantities value which a chive the commercial benefits but qualities and sensitivity for specific qualities still the critical requirement for nanotechnology. Each material will nucleate and grow depending on its environment of precipitation such as pH, concentration of solute, concentration of precipitation agent, and temperature, any change on any one until small value can completely change the mechanisms. the progress of rapid development research in Various methods offering different kinds for making specific control for selective types, shapes, properties, and quantities of NMs in all applications.

Compliance with ethical standards

Acknowledgments

We extend our gratitude and thanks to Al-Karkh University of Science and the College of Science for providing support and providing all the requirements for preparing this work.

References

[1] Firas H. Abdulrazzak , Ahmed M. Abass , Ayad F. Alkaim , Falah H. Hussein,''Comparison between Chemical Vapor Deposition and Flame Fragments Deposition Techniques for Synthesizing Carbon Nanotubes'', NeuroQuantology , 18 (4) pp. 05-10,2020.

[2] Firas H. Abdulrazzak, Ahmed M. Abass, Mohammed, M.K., Radhi, I.M., Abdullatif, A.E., Yaseen, H.M., Yas, D.A., & Alkaim, A.F. Preparation and Characterization of Silver Oxide Nanoparticles (AgNPs) and Evaluation the Ratios of Oxides. Journal of Engineering and Applied Sciences, 14, pp.9177-9184,2019.

[3] Asmaa H. Hammadi, Ahmed M. Jasim, Firas H. Abdulrazzak, Abdulkareem M. A. Al-Sammarraie, Yacine Cherifi, Rabah Boukherroub, and Falah H. Hussein,'' Purification for Carbon Nanotubes Synthesized by Flame Fragments Deposition via Hydrogen Peroxide and Acetone. Materials (Basel). ,13(10):2342. 2020 .

[4] Falah H. Hussein ,Firas H. Abdulrazzak and Ayad F. Alkaim, 2018,willy, chapter 1: Synthesis, Characterization and General Properties of Carbon Nanotubes.

[5] Firas H. Abdulrazzak, Falah H. Hussein, Ayad F. Alkaim, Irina Ivanova, Alexei V. Emeline and Detlef W. Bahnemann,'' Sonochemical/Hydration–Dehydration Synthesis of Pt-TiO2 NPs/ decorated carbon nanotubes with Enhanced Photocatalytic Hydrogen Production Activity'', Photochem. Photobiol. Sci., 15, pp. 1347-135, 2016 .

[6] Satyanarayana T., Sudhakar S. Reddy,'' A Review on Chemical and Physical Synthesis Methods of Nanomaterials'', (IJRASET), 6 (I) 2018 .

[7] Maciej Tulinski and Mieczyslaw Jurczyk, Metrology and Standardization of Nanotechnology: Protocols and Industrial Innovations: chapter 4: Nanomaterials Synthesis Methods, Willy, 2017 .

[8] Rafael S. Geonmonond, Anderson G.M. Da Silva and Pdro H.C. Camargo,''Controlled synthesis of noble metal nanomaterials: motivation, principles, and opportunities in nanocatalysis'', An Acad Bras Cienc,90, pp.719-744, 2018.

[9] Khalisanni K., Xuefei T., Hayyiratul F.Mohd Zaid, Yang T., Chien L. Chew, Dinh-T. Chu, Man K.Lam, Yeek-Chia Ho, Jun W. Lim & Lai C.Wei,'' Advanced in developmental organic and inorganic nanomaterial: a review'', Bioengineered, 11(1)pp. 328–355, 2020 .

[10] Jaison J. , Ahmed B/, Yen S. Chan , Alain D. and Michael K. Danquah,'' Review on nanoparticles and nanostructured materials: history, sources, toxicity and regulations'', Beilstein J. Nanotechnol. 9, pp.1050–1074,2018.

[11] Nguyen T. K. Thanh, N. Maclean, and S. Mahiddine,'' Mechanisms of Nucleation and Growth of Nanoparticles in Solution'', Chem. Rev. 114, pp.7610−7630, 2014 .

[12] Jitendra N. Tiwari, Rajanish N. Tiwari , Kwang S. Kim,'' Zero-dimensional, one-dimensional, two-dimensional and three-dimensional nanostructured materials for advanced electrochemical energy devices'', Prog.s . Mate.Sci., 57(4),pp. 724-803,2012 .

[13] Liane M. Moreau, Don-Hyung Ha, Haitao Zhang, Robert Hovden, David A. Muller, and Richard D. Robinson,'' Defining Crystalline/Amorphous Phases of Nanoparticles through X-ray Absorption Spectroscopy and X-ray Diffraction: The Case of Nickel Phosphide'', Chem. Mate., 25 (12), pp. 2394-2403, 2013 .

[14] Young-Shin Jun, Doyoon Kim, and Chelsea W. Neil ', Heterogeneous Nucleation and Growth of Nanoparticles at Environmental Interfaces,'' Acco. of Chem. Rese., 49 (9), pp.1681-1690,2016.

[15] Lian-Yi Chen, Jia-Quan Xu, Hongseok Choi, Hiromi Konishi, Song Jin6 & Xiao-Chun Li,' Rapid control of phase growth by nanoparticles'', Nat Commun 5, 3879,2014 .

[16] Sarah Fouilloux , Jean Daillant Antoine Thill,''Single step synthesis of 5–30 nm monodisperse silica nanoparticles: Important experimental parameters and modeling'',Colloids and Surfaces A: Physicoch. . Engine. Asp., 393 (5), pp. 122-127,2012