Review Article: Synthesis of Cr_2O_3 nanoparticles by Green Synthesis Method and its Applications

Neera Sharma
Department of Physics, Agra College, Agra, U.P., India
E-mail: neerasharma09@yahoo.in

In this paper green methods of synthesis of Cr_2O_3 nanoparticles are discussed. Microorganisms, plants and fungi can be used for this purpose. Green synthesis is eco-friendly and cost effective. This is one pot synthesis and uses lesser number of chemicals. This method of synthesis is faster than physical and chemical methods of synthesis of nanoparticles. Applications of Cr_2O_3 nanoparticles are also discussed in this paper.

Keywords: Cr_2O_3, Nanoparticles, Green Synthesis.

1. INTRODUCTION

Nanotechnology is one of the most recent active areas of scientific research. It is an interdisciplinary branch that deals with chemistry, physics, biophysics, biology, material science, etc. The various synthesis methods and applications of the nanoparticles is one of the richest classes of the nanotechnology.

The nanoparticles are synthesized by physical or chemical methods, for which two approaches have been employed; one is bottom-up approach and the other is top-down approach [1-5]. The esteemed technological applications of the nanoparticles are due to their unique and compatible properties like thermal, electrical, optical, magnetic, optoelectronic, mechanical, catalytic, physiochemical, etc.

Recently, Chromium oxide nanoparticles have possessed a lot attention due to their outstanding place in the technology. The Chromium holds the oxidation states starting from -4 to +6 whereas only +3 and +6 are the two oxidation states which are stable under environmental condition. Cr_2O_3 nanoparticles have wide band gap [6] which is the main reason that it is extensively studied.

To attain the desired composition and morphology of nanomaterials, it is very necessary to acquire a suitable synthesis process which is really a very challenging task. The various techniques which have been reported in literature for the Cr_2O_3 nanoparticles are gas condensation [7], laser induced deposition [8], hard template pathway with meso porous silica [9], hydrothermal reduction [10], condensation-polymerisation process [11], sono chemical reaction [12], solid thermal decomposition [13], microwave plasma [14], detonation method [15], chemical spray paralysis [16], RF magnetron sputtering [17], mechanical ball milling technique [18] and mechnochemical reaction [19].

For the synthesis of nanoparticles a promising route to attain ecofriendly, low cost and high field is to effectively utilize the assortment of biological material present in nature. It is well known from decades the fungi, plants, bacteria, virus have been used to produce low cost, energy efficient and non-toxic nanoparticles.

2. LITERATURE REVIEW ON GREEN METHODS OF SYNTHESIS OF CR_2O_3 NANOPARTICLES

A propitious way to obtain high yield, eco-friendly low cost and sustainable methods for the synthesis of metal oxide nanoparticles is to exploit the array of biological resources. Indeed, over the years, plants, fungi, viruses, algae, bacteria have been used for the production of energy efficient, low cost and innocuous metal oxide nanoparticles.

It is reported in the literature that Chromium oxide nanoparticles can be synthesized from plant extracts and bacteria. The synthesis of nanoparticles by plant extracts and bacteria is very effective as they are buildup of physicochemical constituents such as glyoxides, polyphenyl, tespenoids, tannin, alkaloids, flavonoids, proteins, amino acids and other heterocyclic compounds, etc. These physicochemicals have high wall bending capacity, are capable of producing large amount of biomass and helps in reducing metal ion. The physicofabrication of nanoparticles is done without using the reducing agents and stabilizers. The physicochemicals are also considered as strong corrosion inhibitors.

Neha Gupta *et. al.* [20] synthesize Cr_2O_3 nanoparticles by *MukiaMaderas patina* and *mulberry* leaves. B T Sone*et et. al.* [21] synthesize Cr_2O_3 nanoparticles by *Callistemon viminalis* flower's extract. K. Anamolai*et et. al.* [22] synthesize Cr_2O_3 nanoparticles by bio sorption and bio reduction with *Bacillus subtitles*. C Ramesh *et. al.* [23] synthesize Cr_2O_3 nanoparticles by *Arachishypogea*leaf extract. Rakesh *et. al.* [24] synthesize Cr_2O_3 nanoparticles by *MukiaMaderas patana* plant extract.

Due to large applications of Chromium oxide nanoparticles, many researchers are working in this field. The results of research are very good. The yield by this method of synthesis is good enough for large scale synthesis.

3. APPLICATIONS OF Cr_2O_3 NANOPARTICLES

Recently Chromium oxide nanoparticles attracted a lot of attention due to their outstanding place in the technology. The Chromium ion holds the oxidation states from -4 to +6 whereas only +3 to +6 are the oxidation states which are stable under environmental conditions. The Cr(IV) are found to be extremely active in the surroundings and can be harmful to plants, animals and humans due to their toxic nature. However, there exist another option Cr(III) which is less mobile, toxic and get quickly precipitate [25].

There are wide range of applications of Chromium oxide nanoparticles such as high temperature ceramics, semiconductors, magnetic materials, coating materials, a humidity sensor, catalysts, super hard materials, etc. Some applications are listed here with reference:

1. Cr_2O_3 nanoparticles have distinct applications such as coating materials [26,27], Corrosion resistant material [28], green pigment [24], in liquid crystal displays [29], as heterogeneous catalyst [23,30] and as high temperature resistant material [30].

2. It is observed by researchers that the growth of *Klebsiella pneumonia* decreases significantly with the increase in the concentration of Cr_2O_3 nanoarticles [31].
3. These nanoparticles can be used for gas sensors [32].
4. Cr_2O_3 nanoparticles shows good antibacterial activity against enterococcus faceless [34,35].
5. These nanoparticles can be used for applications like stropping knives, a precursor to the magnetic pigment glasses, paints and inks [31].
6. Cr_2O_3 nanoparticles can be used as coating materials for refractory, wear resistance, thermal protection and humidity sensing [3].
7. It is observed that Cr_2O_3 nanoparticles can be used for heavy metal absorption from aqueous systems [11].

4. CONCLUSION

The green synthesis of Chromium oxide nanoparticles is an appealing subject for ongoing scientific temptation and have been enormously explored in material sciences, because of their physicochemical properties. Cr_2O_3 nanoparticles can be synthesized on large scale by methods of green synthesis. Green synthesis is eco-friendly and cost effective technique. This technique uses lesser number of chemicals and it is one pot synthesis. By this method nanoparticles can be synthesized using lesser number of resources.

Cr_2O_3 nanoparticles have large number of applications in industry. Hence, a suitable method of synthesis is required which can be green method of synthesis. We can say, it is time for a vast search for the preparation techniques of Chromium oxide nanoparticles by plant leaf extract.

REFERENCES

[1] M. Zheng, Wenyang Li, Mengjiao Xu, Ning Xu, Peng Chen, Min Han, and Bo Xie; "Strain sensors based on chromium nanoparticle arrays", Nanoscale, Vol. 6(8), pp. 3930-393, 2014. DOI: 10.1039/C3NR04135B

[2] M.M. Abdullah, Fahd M. Rajab and Saleh M. Al-Abbas; "Structural and optical characterization of Cr_2O_3 nanostructures: Evaluation of its dielectric properties", Aip Advances, Vol. 4(2), pp. 027121, 2014. DOI: 10.1063/1.4867012

[3] Salah A. Makhlouf, Zinab H. Bakr, H. Al-Attar and M.S. Moustafa; "Structural, morphological and electrical properties of Cr_2O_3 nanoparticles", Materials Science and Engineering: B, Vol. 178(6), pp. 337-343, 2013. DOI: 10.1016/j.mseb.2013.01.012

[4] Melissa A. Maurer-Jones, Ian L. Gunsolus, Catherine J. Murphy and Christy L. Haynes; "Toxicity of engineered nanoparticles in the environment", Analytical chemistry, Vol. 85(6), pp. 3036-3049, 2013. DOI: 10.1021/ac303636s

[5] I. Ban, J. Stergar, M. Drofenik, G. Ferk and D. Makovec; "Synthesis of chromium-nickel nanoparticles prepared by a microemulsion method and mechanical milling", Acta Chimica Slovenica, Vol. 60(4), pp. 750-755, 2014.

[6] H.I. Gomes, C. Dias-Ferreira and A.B. Ribeiro; "Electrokinetic enhanced transport of zero valent iron nanoparticles for chromium (VI) reduction in soils", Chemical Engineering Transactions, Vol. 28, pp. 1-6, 2012.

[7] C.R. Tomachuk, A.R. Di Sarli and C.I. Elsner; "Anti-corrosion performance of Cr+ 6-free passivating layers applied on electrogalvanized", Materials Science and Applications, Vol. 1(4), pp. 202-209, 2010.

[8] T. Tsoncheva, J. Roggenbuck, D. Paneva, M. Dimitrov, I. Mitov and M. Fröba; "Nanosized iron and chromium oxides supported on mesoporous CeO_2 and SBA-15 silica: Physicochemical and catalytic study", Applied Surface Science, Vol. 257(2), pp. 523-530, 2010. DOI: 10.1016/j.apsusc.2010.07.027

[9] R.J. Griffitt, K. Hyndman, N.D. Denslow and D.S. Barber; "Comparison of molecular and histological changes in zebrafish gills exposed to metallic nanoparticles", Toxicological Sciences, Vol. 107(2), pp. 404-415, 2009. DOI: 10.1093/toxsci/kfn256

[10] A. Demessence, P. Horcajada, C. Serre, C. Boissière, D. Grosso, C. Sanchez and G. Férey; "Elaboration and properties of hierarchically structured optical thin films of MIL-101 (Cr)", Chemical communications, Vol. 46, pp. 7149-7151, 2009.

[11] S.M. El-Sheikh, R.M. Mohamed and O.A. Fouad; "Synthesis and structure screening of nanostructured chromium oxide powders", Journal of alloys and compounds, Vol. 482(1-2), pp. 302-307, 2009.

[12] L. Chen, Z. Song, X. Wang, S.V. Prikhodko, J. Hu, S. Kodambaka and Ryan Richards; "Three-dimensional morphology control during wet chemical synthesis of porous chromium oxide spheres", ACS applied materials & interfaces, Vol. 1(9), pp. 1931-1937, 2009. DOI: 10.1021/am900334q

[13] A. Kahru, H.C. Dubourguier, I. Blinova, A. Ivask and K. Kasemets; "Biotests and biosensors for ecotoxicology of metal oxide nanoparticles: a minireview", Sensors, Vol. 8(8), pp. 5153-5170, 2008. DOI: 10.3390/s8085153

[14] C. Quintelas, B. Fernandes, J. Castro, H. Figueiredo and T. Tavares; "Biosorption of Cr (VI) by three different bacterial species supported on granular activated carbon-a comparative study", Journal of Hazardous Materials, Vol. 153(1-2), pp. 799-809, 2008. DOI: 10.1016/j.jhazmat.2007.09.027

[15] G. Lota, E. Frackowiak, J. Mittal and M. Monthioux; "High performance supercapacitor from chromium oxide-nanotubes based electrodes", Chemical physics letters, Vol. 434(1-3), pp. 73-77, 2007. DOI: 10.1016/j.cplett.2006.11.089

[16] M.N. Moore; "Do nanoparticles present ecotoxicological risks for the health of the aquatic environment?", Environment international, Vol. 32(8), pp. 967-976, 2006. DOI: 10.1016/j.envint.2006.06.014

[17] M. Luis and Liz-Marzán; "Tailoring surface plasmons through the morphology and assembly of metal nanoparticles", Langmuir, Vol. 22(1), pp. 32-41, 2006. DOI: 10.1021/la0513353

[18] Y. Sun and Y. Xia; "Shape-controlled synthesis of gold and silver nanoparticles", Science, Vol. 298(5601), pp. 2176-2179, 2002. DOI: 10.1126/science.1077229

[19] Christof M. Niemeyer; "Nanoparticles, proteins, and nucleic acids: biotechnology meets materials science", Angewandte Chemie International Edition, Vol. 40(22), pp. 4128-4158, 2001. DOI: 10.1002/1521-3773(20011119)40:22<4128::AID-ANIE4128>3.0.CO;2-S

[20] Neha Gupta and Resmi S.P.; "Synthesis of chromium (V) oxide nanoparticles by Mukiamaderaspatana and mulberry leaves extract and its characterization", Imperial Journal of Interdisciplinary Research, Vol. 2(11), pp. 532-535, 2016.

[21] B.T. Sone, E. Manikandan, A. Gurib-Fakim and M. Maaza; "Single-phase α-Cr_2O_3 nanoparticles' green synthesis using *Callistemon viminalis'* red flower extract", Green Chemistry Letters and Reviews, Vol. 9(2), pp. 85-90, 2016. DOI: 10.1080/17518253.2016.1151083

[22] A. Kanakalakshmi, A.M. Nair, S. Chinnaraju and S. Kuppusamy; "Chromium (III) nanoparticle synthesis using the biosorption and bioreduction with Bacillus subtilis: effect of pH and temperature", International Journal of ChemTech Research, Vol. 6(3), pp. 1910-1912, 2014.

[23] C. Ramesh, K. Mohan Kumar, M. Senthil and V. Ragunathan; "Antibacterial activity of Cr_2O_3 nanoparticles against E. coli; reduction of chromate ions by Arachishypogaea leaves", Archives of Applied Science Research, Vol. 4(4), pp. 1894-1900, 2012.

[24] Rakesh, S. Ananda and N. Gowda; "Synthesis of chromium (III) oxide nanoparticles by electrochemical method and Mukia Maderaspatana plant extract, characterization, $KMnO_4$ decomposition and antibacterial study", Modern Research in Catalysis, Vol. 2(4), pp. 127-135, 2013.

[25] R.N. Jyothi, N.A. Mohammad Farook, M. Cho and J. Shim; "Analysis and speciation of chromium in environmental matrices by various analytical techniques", Asian Journal of Chemistry, Vol. 25(8), pp. 4125-4136, 2013.

[26] S.A. Johari and S. Asghari; "Acute toxicity of titanium dioxide nanoparticles in Daphnia magna and Pontogammarus maeoticus", Journal of Advances in Environmental Health Research, Vol. 3(2), pp. 111-119, 2015.

[27] M.A. Maurer-Jones, I.L. Gunsolus, C.J. Murphy and C.L. Haynes; "Toxicity of engineered nanoparticles in the environment." Analytical chemistry, Vol. 85(6), pp. 3036-3049, 2013. DOI: 10.1021/ac303636s

[28] M. Horie, K. Nishio, S. Endoh, H. Kato, K. Fujita, A. Miyauchi, A. Nakamura, S. Kinugasa, K. Yamamoto, E. Niki, Y. Yoshida and H. Iwahashi; "Chromium(III) oxide nanoparticles induced remarkable oxidative stress and apoptosis on culture cells", Environ Toxicol., Vol. 28(2), pp. 61-75, 2013,

[29] N. Kohli, O.S. Kang, M.P. Singh and R.C. Singh; "Fabrication of LPG Sensors Based Upon Chemically Tailored Sizes of Chromium Oxide Nanoparticles", 14th International Meeting on Chemical Sensors - IMCS 2012, 2012.

[30] J. Zhu, H. Gu, S.B. Rapole, Z. Luo, S. Pallavkar, N. Haldolaarachchige, T.J. Benson, T.C. Ho, J. Hopper, D.P. Young, S. Wei and Z. Guo; “Looped carbon capturing and environmental remediation: case study of magnetic polypropylene nanocomposites", RSC advances, Vol. 2(11), pp. 4844-4856, 2012.

[31] V. Jaswal, A. Arora, M. Kinger, V. Gupta and J. Singh; "Synthesis and characterization of chromium oxide nanoparticles", Oriental Journal of Chemistry, Vol. 30(2), pp. 559-566, 2014. DOI: 10.13005/ojc/300220

[32] P. Gibot, M. Comet, A. Eichhorn, F. Schnell, O. Muller, F. Ciszek, Y. Boehrer and D. Spitzer; "Highly insensitive/reactive thermite prepared from Cr_2O_3 nanoparticles", Propellants, Explosives, Pyrotechnics, Vol. 36(1), pp. 80-87, 2011.

[33] I. Khatoon, P. Vajpayee, G. Singh, A.K. Pandey, A. Dhawan, K.C. Gupta and R. Shanker; “Determination of internalization of chromium oxide nano-particles in Escherichia coli by flow cytometry”, Journal of biomedical nanotechnology, Vol. 7(1), pp. 168-169, 2011.

[34] G. Singh, P. Vajpayee, I. Khatoon, A. Jyoti, A. Dhawan, K.C. Gupta and R. Shanker; "Chromium oxide nano-particles induce stress in bacteria: probing cell viability", Journal of biomedical nanotechnology, Vol. 7(1), pp. 166-167, 2011.

[35] P. Sangwan, H. Kumar and S.S. Purewal; “Antibacterial activity of chemically synthesized chromium oxide nanoparticles against Enterococcus faecalis”, Int. J. Adv. Tech. Eng. Sci, Vol. 4(8), pp. 550-557, 2016.