

# Controlled Synthesis and Characterization of Noble Metal Nanoparticles

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## ABSTRACT

In this work, monodispersed, well-shaped platinum (3.2 - 6.4 nm), rhodium (2.4 - 5.1 nm), and palladium (3.2 - 5.3 nm) nanoparticles capped with poly(vinylpyrrolidone) (PVP) were synthesized by a polyol reduction method in an ethylene glycol solution at temperature of 190°C. The influences of synthetic parameters on the size and morphology of the noble metal nanoparticles have been systematically investigated. The noble metal nanoparticles were characterized by means of UV-vis, laser scattering particle size distribution analysis (LSPSDA) and transmission electron microscopy (TEM). The experimental results showed that the particle size of metal nanoparticles, the morphology of which was spherical, increased with the raise of metal precursor concentration as well as the amount of PVP. The optimal molar ratio of PVP/metal and metal precursor concentration for the fabrication of Pt, Rh, and Pd nanoparticles with uniform distribution were 10 and 0.1 mM, respectively. The morphologies of the Rh nanoparticles with the size of 5.1 nm were polygons, including hexagons, pentagons, and triangles.

**Keywords:** Polyol Reduction; Pt; Rh; Pd Nanoparticles; Poly(vinylpyrrolidone)

## 1. Introduction

Noble metal nanoparticles (NPs) with a narrow size distribution are valuable technological importance because of their unique physico-chemical properties and applications in the fields of catalysis, information storage, optoelectronics, sensors, fine chemicals synthesis, oil refining processes, and fuel cell technology. Uniformity of particle size minimizes the dispersion of important properties that are critical in these operations, such as surface chemical activity and magnetic as well as electronic properties [1-7]. Thus, much attention has been paid in recent years to develop methods of synthesizing monodispersed and size/shape controlled noble metal nanoparticles (Pt [8-10], Rh [11-13], Pd [14,15], Ir [16], Au [17,18], and Ag [19,20]) by tuning the particle growth kinetics in the processes of fabricating. Recent years, many effective methods have been developed including seeded growth by polyol reduction [21], thermolysis of organometallics [22], modified polyol methods [23], and micelle techniques [24]. Since Pt, Rh, and Pd are important noble metals, the synthesis of the noble metal nanoparticles with size and shape regulated has thus become a fundamental research focus. For instance, Somorjai [11,21] reported that the Rh nanocrystals with morphologies of multipod, cube, horn, and cuboctahedra were synthesized successfully by the seeded growth in a

polyol system. Xia and co-workers [23] investigated the synthesis and stability of Rh multipods in a polyol system, which showed interesting surface plasmonic properties. By an organometallic approach, Son and co-workers [22] prepared monodispersed oleyl amine-capped Rh tetrahedral nanocrystals, which displayed excellent arenes hydrogenation activities. Mukul [25] had demonstrated 1D nanostructures composed of Rh (0) and Rh (I) prepared by solution-phase synthetic approach. However, there was little work on the systematically investigation of size control in fabricating monodispersed Pt, Rh, and Pd nanoparticles.

In this paper, we report a one-step polyol synthesis of monodispersed, well-shaped Pt (3.2 - 6.4 nm), Rh (2.4 - 5.1 nm), and Pd (3.2 - 5.3 nm) nanoparticles at temperature of 190°C in a polyol system, using ethylene glycol as the reducing solvent and poly(vinylpyrrolidone) as the capping agent. The varieties of particle size with an increasing in precursor concentration and the ratio of metal/PVP were illustrated. Especially, Rh nanoparticles in a smaller size (5.1 nm) were polygons, such as hexagons, pentagons, and triangles. The size of the Rh nanoparticles is smaller than that reported before.

## 2. Experimental

### 2.1. Chemicals and Reagents

Hexachloroplatinum Acid Hydrate ( $H_2PtCl_6 \cdot 6H_2O$ , 99.9%),

\*Corresponding author.

# Controlled Synthesis And Characterization Of Nobel Metal

**Naznin Sultana, Sanchita  
Bandyopadhyay-Ghosh, Chin Phong  
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## **Controlled Synthesis And Characterization Of Nobel Metal:**

**Metals in Medicine** Sonali Sundram, Rishabha Malviya, GSN Koteswara Rao, 2025-02-03 Metals in Medicine published in two volumes provides detailed information on and applications of metal-containing compounds that function as essential tools in medical science for the imaging and diagnosis of disease as well for the prevention and treatment of many diseases Volume 2 deals with the application of metal active drugs for disease treatment and diagnosis It explores the application of gold silver zinc and other metallic nanoparticles for tissue engineering as well as their role in cancer therapy offering real life applications Volume 1 Metals for Tissue Engineering and Pharmaceutical Applications introduces metallodrugs and their applications in the biomedical field including for tissue engineering drug delivery bioimaging biosensing and bone tissue engineering

**Nanobiotechnology** Sougata Ghosh, Thomas J Webster, 2021-05-20 Nanobiotechnology Microbes and Plant Assisted Synthesis of Nanoparticles Mechanisms and Applications covers in detail the green synthesis of nanostructures of tailor made size shape and physico chemical and opto electronic properties The rationale behind the selection of bacteria cyanobacteria algae fungi virus and medicinal plants for the synthesis of biologically active exotic nanoparticles for biomedical applications is also part of this book It also explores metal recovery bioconversion detoxification and removal of heavy metals using nanobiotechnology and discusses the potential of nanobiotechnology to address environmental pollution and toxicity The book further covers the economic and commercial aspects of such green nanobiotechnology initiatives its current status in intellectual property rights like patents filed so far globally technology transfers and market potential This information enables one to decipher the scope of biogenic nanoparticles and its prospects Provides an overview on the general and applied aspects on nanotechnology Gives the scope of exploring bacteria fungi algae virus and medicinal plants for the synthesis of exotic nanoparticles Furnishes a comprehensive report on the underlying molecular mechanisms behind the biosynthesis of nanoparticles Outlines sustainable alternative strategies of bioremediation of heavy metals metal recovery detoxification and bioconversion using nanobiotechnology Explores the promises of patenting technology transfer and commercialization potential of biogenic nanoparticles

**Synthesis and Applications of Nanoparticles** Atul Thakur, Preeti Thakur, S.M. Paul Khurana, 2022-06-20 This book provides thorough information on various nanomaterials techniques for their synthesis and characterization and examines their agricultural environmental biomedical and clinical applications The initial part of the book presents different nanomaterials covers various physical chemical and biological methods for their synthesis and reviews techniques to characterize their physicochemical and biological properties Subsequently the chapters of the book focus on the innovative applications of nanomaterials in disease diagnosis tissue engineering regenerative medicine and cancer therapy It also explores the green biosynthesis of nanomaterials and highlights their biological applications Towards the end the book examines the toxicity and biocompatibility of various nanomaterials It aims to serve as a resource guide for researchers and biomedical clinicians working with nanomaterials

**Research Anthology on**

**Synthesis, Characterization, and Applications of Nanomaterials** Management Association, Information Resources, 2021-03-19 The use of nanotechnologies continues to grow as nanomaterials have proven their versatility and use in many different fields and industries within the scientific profession Using nanotechnology materials can be made lighter more durable more reactive and more efficient leading nanoscale materials to enhance many everyday products and processes With many different sizes shapes and internal structures the applications are endless These uses range from pharmaceuticals to materials such as cement or cloth electronics environmental sustainability and more Therefore there has been a recent surge of research focused on the synthesis and characterizations of these nanomaterials to better understand how they can be used their applications and the many different types The Research Anthology on Synthesis Characterization and Applications of Nanomaterials seeks to address not only how nanomaterials are created used or characterized but also to apply this knowledge to the multidimensional industries fields and applications of nanomaterials and nanoscience This includes topics such as both natural and manmade nanomaterials the size shape reactivity and other essential characteristics of nanomaterials challenges and potential effects of using nanomaterials and the advantages of nanomaterials with multidisciplinary uses This book is ideally designed for researchers engineers practitioners industrialists educators strategists policymakers scientists and students working in fields that include materials engineering engineering science nanotechnology biotechnology microbiology drug design and delivery medicine and more **Biosynthesized Nanomaterials**, 2021-07-07 CAC series highlights new advances in the field This Volume 94 presents interesting chapters on the recent advances in the role of nanoparticles in plant biotechnology Each chapter is written by international experts in the respective fields Provides the authority and expertise of leading contributors from an international board of authors Presents the latest release in the Comprehensive Analytical Chemistry series Updated release includes the latest information on Biosynthesized nanomaterials **Microemulsions** Reza Najjar, 2012-03-16 The rapidly increasing number of applications for microemulsions has kept this relatively old topic still at the top point of research themes This book provides an assessment of some issues influencing the characteristics and performance of the microemulsions as well as their main types of applications In chapter 1 a short introduction about the background various aspects and applications of microemulsions is given In Part 2 some experimental and modeling investigations on microstructure and phase behavior of these systems have been discussed The last two parts of book is devoted to discussion on different types of microemulsion s applications namely use in drug delivery vaccines oil industry preparation of nanostructured polymeric metallic and metal oxides materials for different applications **Asymmetric Synthesis of Drugs and Natural Products** Ahindra Nag, 2018-01-12 This book focuses on different techniques of asymmetric synthesis of important compounds such as drugs and natural products It gives insightful information on recent asymmetric synthesis by Inorganic Organic and Enzymatic combinations It also emphasizes chiral compounds and design of new catalyst for synthesis of compounds *Advances in Nanotechnology and the*

*Environment* Juyoung Kim, 2016-04-19 Nanoparticles and nano sized materials created by nanotechnology NT have been considered unique and sole solutions to overcome the limitations of other technologies and widen their applications Although these materials have been widely used in environmental technology ET most environmental applications of nanoparticles were limited to th **Optical Properties of Metal Oxide Nanostructures** Vijay Kumar, Irfan Ayoub, Vishal

Sharma, Hendrik C. Swart, 2023-09-23 This book highlights the optical properties of metal oxides at both the fundamental and applied level and their use in various applications The book offers a basic understanding of the optical properties and related spectroscopic techniques essential for anyone interested in learning about metal oxide nanostructures This is partly due to the fact that optical properties are closely associated with other properties and functionalities e g electronic magnetic and thermal which are of essential significance to many technological applications such as optical data communications imaging lighting and displays life sciences health care security and safety The book also highlights the fundamentals and systematic developments in various optical techniques to achieve better characterization cost effective user friendly approaches and most importantly state of the art developing methodologies for various scientific and technological applications It provides an adequate understanding of the imposed limitations and highlights the prospects and challenges associated with optical analytical methods to achieve the desired performance in targeted applications *Characterization of Metal and Polymer*

*Surfaces V1* Lieng-Huang Lee, 2012-12-02 Characterization of Metal and Polymer Surfaces Volume 1 Metal Surfaces presents the proceedings of the Symposium on Advances in Characterization of Metal and Polymer Surfaces held in New York on April 5 8 1976 This book provides information pertinent to surface science and discusses the applications of surface analyses to polymer technology Organized into five parts encompassing 19 chapters this compilation of papers starts with an overview of the important innovations of surface analyses and discusses the possible applications of each method to polymer technology This text then explores atom probe field ion microscopy which is the most sensitive micro analytical tool that combines the single atom resolution of a field ion microscope with mass spectrometric single ion identification Other chapters discuss the application of Mossbauer spectroscopy as a technique for studying corrosion phenomena The final chapter deals with the capabilities and limitations of the method of inelastic electron tunnelling This book is a valuable resource for analytical and polymer chemists *Hybrid Nanomaterials for Sustainable Applications* Janardhan Reddy Koduru, Rama Rao Karri, Nabisab

Mujawar Mubarak, 2023-04-11 Hybrid Nanomaterials for Sustainable Applications Case Studies and Applications brings together the latest advances in hybrid nanocomposites and their diverse applications for improved sustainability The book begins by introducing hybrid nanomaterials synthesis strategies and approaches to production for engineering applications Subsequent sections provide chapters on key application areas including water purification nanobiotechnologies energy storage and biomedicine presenting approaches for sustainable application for each usage Throughout the book key challenges are addressed with case studies used to support implementation and improve end applications This is a valuable

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*Energy and Environmental Engineering* Yijin Wu, 2015-02-04 The 2014 International Conference on Energy and Environmental Engineering ICEEE 2014 was held September 21 22 2014 in Hong Kong This proceedings volume assembles papers from various professionals leading researchers engineers scientists and students and presents innovative ideas and research results focused on Energy and Environmental Engine

**Handbook of Polymer Synthesis, Characterization, and Processing** Enrique Saldivar-Guerra, Eduardo Vivaldo-Lima, 2013-02-28 Covering a broad range of polymer science topics Handbook of Polymer Synthesis Characterization and Processing provides polymer industry professionals and researchers in polymer science and technology with a single comprehensive handbook summarizing all aspects involved in the polymer production chain The handbook focuses on industrially important polymers analytical techniques and formulation methods with chapters covering step growth radical and co polymerization crosslinking and grafting reaction engineering advanced technology applications including conjugated dendritic and nanomaterial polymers and emulsions and characterization methods including spectroscopy light scattering and microscopy

Advanced Carbon Materials and Technology Ashutosh Tiwari, S. K. Shukla, 2014-01-28 The expansion of carbon materials is multidisciplinary and is related to physics chemistry biology applied sciences and engineering The research on carbon materials has mostly focused on aspects of fundamental physics as they unique electrical thermal and mechanical properties applicable for the range of applications The electrons in graphene and other derived carbon materials behave as dirac fermions due to their interaction with the ions of the lattice This direction has led to the discovery of new phenomena such as Klein tunneling in carbon based solid state systems and the so called half integer quantum Hall effect Advanced Carbon Materials and Technology presents cutting edge chapters on the processing properties and technological developments of graphene carbon nanotubes carbon fibers carbon particles and other carbon based structures including multifunctional graphene sheets graphene quantum dots bulky balls carbon balls and their polymer composites This book brings together respected international scholars writing on the innovative methodologies and strategies adopted in carbon materials research area including Synthesis characterization and functionalization of carbon nanotubes and graphene Surface modification of graphene Carbon based nanostructured materials Graphene and carbon nanotube based electrochemical bio sensors for environmental monitoring Carbon catalysts for hydrogen storage materials Optical carbon nanoobjects Graphene and carbon nanotube based biosensors Carbon doped cryogel films Bioimpact of carbon nanomaterials Photocatalytic nature of carbon

nanotube based composites Engineering behavior of ash fills Fly ash syntactic foams microstructure      *Molecular Characterization and Analysis of Polymers* John M. Chalmers, Robert J. Meier, 2008-12-09 Written by expert contributors from the academic and industrial sectors this book presents traditional and modern approaches to polymer characterization and analysis The emphasis is on pragmatics problem solving and property determination real world applications provide a context for key concepts The characterizations focus on organic polymer and polymer product microstructure and composition Approaches molecular characterization and analysis of polymers from the viewpoint of problem solving and polymer property characterization rather than from a technique championing approach Focuses on providing a means to ascertaining the optimum approach or technique s to solve a problem measure a property and thereby develop an analytical competence in the molecular characterization and analysis of real world polymer products Provides background on polymer chemistry and microstructure discussions of polymer chain morphology degradation and product failure and additive analysis and considers the supporting roles of modeling and high throughput analysis      Tissue Engineering Strategies for Organ Regeneration Naznin Sultana, Sanchita Bandyopadhyay-Ghosh, Chin Fhong Soon, 2020-02-04 Tissue Engineering Strategies for Organ Regeneration addresses the existing and future trends of tissue engineering approaches for organ tissue regeneration or repair This book provides a comprehensive summary of the recent improvement of biomaterials used in scaffold based tissue engineering and the tools and different protocols needed to design tissues and organs The chapters in this book provide the in depth principles for many of the supporting and enabling technologies including the applications of BioMEMS devices in tissue engineering and the combination of organoid formation and three dimensional 3D bioprinting The book also highlights the advances and strategies for regeneration of three dimensional microtissues in microcapsules tissue reconstruction techniques and injectable composite scaffolds for bone tissue repair and augmentation Key Features Addresses the current obstacles to tissue engineering applications Provides the latest improvements in the field of integrated biomaterials and fabrication techniques for scaffold based tissue engineering Shows the influence of microenvironment towards cell biomaterials interactions Highlights significant and recent improvements of tissue engineering applications for the artificial organ and tissue generation Describes the applications of microelectronic devices in tissue engineering Describes different current bioprinting technologies      *Intelligent System, Applied Materials and Control Technology* J.H. Wu, 2013-01-11 Selected peer reviewed papers from the 2013 International Conference on Intelligent System Applied Materials and Control Technology GSAMCT 2013 January 13 15 2013 Taiyuan Shanxi China      **Molecular Characterization and Analysis of Polymers** Mr. Rohit Manglik, 2024-01-20 EduGorilla Publication is a trusted name in the education sector committed to empowering learners with high quality study materials and resources Specializing in competitive exams and academic support EduGorilla provides comprehensive and well structured content tailored to meet the needs of students across various streams and levels      Corrosion Prevention Nanoscience Berdimurodov Elyor Tukhlievich, Chandrabhan Verma, 2023-07-24

Recently surface engineered and modified nanomaterials have been developed as corrosion inhibitors for different metals alloys in coating and solution phases This book covers current emerging trends and applications in nanomaterials and nanotechnologies and their applications in corrosion prevention It offers synthesis surface modification for enhanced dispersibility and protection composite formation and their anticorrosive applications **Graphene-Rubber**

**Nanocomposites** Titash Mondal, Anil K. Bhowmick, 2022-10-24 Since the Nobel Prize for the discovery of graphene was presented in 2010 graphene has been frequently leveraged for different applications Owing to the strategic importance of elastomer based products in different segments graphene and its derivatives are often added to different elastomers to improve their properties Graphene Rubber Nanocomposites Fundamentals to Applications provides a comprehensive and innovative account of graphene rubber composites Features Provides up to date information and research on graphene rubber nanocomposites Presents a detailed account of the different niche applications ranging from sensors flexible electronics to thermal and EMI shielding materials Offers a comprehensive know how on the structure property relationship of graphene rubber nanocomposites Covers the characterization of graphene based elastomeric composition Delivers a comprehensive understanding of the structure of the graphene including its chemical modification for usage in elastomer composites This book will be a valuable resource for graduate level students researchers and professionals working in the fields of materials science polymer science nanoscience and technology rubber technology chemical engineering and composite materials



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