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Tel No. (091)(011) 28031032, 28031039, 28031044, 28031053 Fax No. 011 28031583, 28031432,
E-mail: delhi-patent@nic.in
Web Site : www.ipindia.nic.in

Application Type : ORDINARY APPLICATION

To
FAIZ MOHAMMAD
DR. FAIZ MOHAMMAD PROFESSOR IN THE DEPARTMENT OF APPLIED CHEMISTRY, ALIGARH MUSLIM UNIVERSITY, ALIGARH-202002, INDIA.

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Received documents purporting be to an application for a patent numbered “2398/DEL/2010” dated “06/10/2010 12:23:17” by “FAIZ MOHAMMAD” of “PROFESSOR IN THE DEPARTMENT OF APPLIED CHEMISTRY, ALIGARH MUSLIM UNIVERSITY, ALIGARH-202002, INDIA.” relating to “A SIMPLE ROUTE TO PREPARE EMERALDINE BASE NANOPARTICLES” together with the “Complete Specification” and fee(s) of Rs. 1000 (One Thousand only)

Note: Time to file a request for examination is 48 months from the date of Priority or date of filing of Application whichever is earlier.

for Controller of Patents & Designs
THE PATENT ACT, 1970
COMPLETE SPECIFICATION
SECTION 10

“A SIMPLE ROUTE TO PREPARE EMERALDINE BASE NANOPARTICLES”

Faiz Mohammad and Shahid Pervez Ansari
Indian Nationals
of
Department of Applied Chemistry
Faculty of Engineering and Technology
Aligarh Muslim University
Aligarh-202002, India.
The following specification particularly describes and ascertains the nature of this invention and the manner in which it is to be performed.

The present invention relates to a procedure of “a simple route to prepare emeraldine base nanoparticles”

**BACKGROUND:**

Polymers due to their low electrical conductivity were mainly used as insulating materials. A breakthrough came with the in 1977 when MacDiarmid, Heeger, and Shirakawa discovered that exposure of conjugated polymer polyacetylene to iodine vapor yielded an electrically conducting material. Although their polyacetylene exhibits good electrical properties, its application is limited because of its poor stability in air and complicated synthesis methods. They were later awarded Nobel Prize in 2000. Since then, research in the field of conducting polymers was intensified searching for newer cheaper and smarter conducting polymer. During the meantime many such polymers were discovered such as polyaniline (PAni), polypyrrole (PPy), polythiophene (PTh) etc. These polymers have gained significant prominence recently because of their stability in air and optical and electrical properties.

Polyaniline is unique among the family of conjugated polymers and has attracted considerable attention due to its low cost, simple synthesis, good environmental stability, simple nonredox doping/dedoping chemistry based in acid/base reactions, and favorable optical and electrical properties. It has found potential applications in electronic and optical devices such as batteries, artificial muscles, electromagnetic shielding devices, corrosion protection coatings, sensors, capacitors, hydrogen storage, fuel cells etc.

Polyaniline was originally known in 1835 as “aniline black”, a term used for any product obtained by the oxidation of aniline. Conducting properties of polyaniline were rediscovered in the early 1980s and PAni was found to have wide ranging application in various fields.
Polyaniline can be synthesized by both the electrochemical and chemical oxidative polymerization in acidic, mildly acidic and even neutral media. However, the results are very different in each situation. This may be well understood from the opinion of Prof. A.G. MacDiarmid that “there are as many different types polyaniline as there are people who synthesize it”. The conducting form of polyaniline is termed as emeraldine salt whereas the nonconducting form as emeraldine base.

In recent past, the research on polyaniline and its derivatives was mainly focused on making it more processible and commercially available. It has experienced a great leap with the advent of nanoscience and nanotechnology in recent years. Synthesizing nanostructures of this unique conducting polymer has attracted special attention these days. The hope is that nanostructured polyaniline will offer better performance or new properties compared with its conventional bulk counterpart. Various research groups have conducted works involving synthesis of polyaniline nanofibers and nanoparticles. Few of these reports may be summarized as follows:

F. Yan and G. Xue prepared nanoscopic polyaniline particles in a stable water-oil microemulsion using sodium dodecylbenzenesulfonate (SDBA) which acts as surfactant as well as dopant in the acidic reaction media. *J. Mater. Chem.* 9, 3035-3039 (1999).


Han et. al. carried chemical oxidative polymerization of aniline in micellar solution of dodecylbenzenesulphonic acid (DBSA, anionic surfactant) to obtain conductive polyaniline nanoparticles. *Synthetic Metals* 126, 53-60 (2002).

Park et. al. synthesized monodispersed polyaniline nanoparticles by oxidative dispersion polymerization using poly(sodium-4-styrenesulfonate) (PSSA) as both a polymeric stabilizer and a doping agent due to its acidity. Current Applied Physics 4, 581-583 (2004).


S. Dorey et.al. reported the synthesis of polyaniline (PAni) suspension of particles with size of about 2–3 nm. This nano-colloid was obtained by the oxidative polymerization aniline in dilute and semi-dilute solutions of sodium poly(styrenesulfonate). Polymer 46, 1309–1315, (2005).

Cholli et. al. used biocatalytic approach to prepare polyaniline nanoparticles, however, they obtained it as a composite followed by separation of PAni nanoparticles from these composites. IUPAC Pure & Applied Chemistry 97, 339-344 (2005).


Jing et. al. used the conventional oxidation route to prepare polyaniline nanoparticles but used ultrasonic irradiation instead of mechanical mixing to obtain more uniform nanostructures. Ultrasonics Sonochemistry 14, 75–80 (2007).
Chen et al. prepared a series of polyaniline (PAni) nanostructures from fiber to star-like, net-like and coral ball like by controlling the synthesis conditions such as monomer/stabilizer ratio, pH and reagent adding method and rate by diffusion polymerization. C. R. Chimie 11, 84-89 (2008).

Ganeshan et al. prepared polyaniline nanoparticles with size ranging from 20 nm to 40 nm by the pulsed sonoelectrochemical method. Synthetic Metals 158, 848-853 (2008).

Tran et al. presented a bulk and template-free method to synthesize nanofibers of substituted polyanilines. Macromolecules 41, 7405-7410 (2008).


Xing et al. prepared polyaniline (PAni) nanofibers via interfacial polymerization method. In this method, aniline dissolved in xylene that is immiscible in water, was directly added into the aqueous solution of the oxidant under stirring. The polymerization was carried out at the interface formed between the organic liquid drops and the aqueous solution. Synthetic Metals 158, 59–63 (2008).


Han et al. prepared organic solvent dispersible dodecylbenzenesulfonic acid doped polyaniline (PAni) from DBSA micelles and with ammonium persulfate (APS) as an oxidant in hexane by one-step polymerization. Synthetic Metals 159, 123-131 (2009).
Rahy et al. reported that nano-emulsions can be creatively used as a morphology selective synthesis method to prepare not only nano-grains but also nano-fibers with high selectivity. Polym. Adv. Technol (2009) DOI: 10.1002/pat.1562.

Liu et al. carried out the chemical oxidative polymerization of aniline on solid substrates treated with Au nanoparticles (Au-NPs) deposition and 4-aminothiophenol (ATP) modification. Polyaniline (PANI) fibers were obtained in micro-/nano-size with two-dimensional network structures. Synthetic Metals 159, 1077–1081 (2009).

Zhang et al. presented a new approach for the synthesis of polyaniline nanofibers under pseudo-high dilute conditions in aqueous system. Synthetic Metals 159, 1508–1511 (2009).

Zhang et al. prepared highly crystalline polyaniline (PANI) nanofibers with 16–23 nm in diameter by using FeCl₃·6H₂O as the oxidant in the presence of inorganic acids without any external template. Materials Chemistry and Physics 115, 275–279 (2009).

Fei et al. basically used template guided method to prepare cubic and spherical nanostructures of polyaniline. ACS Nano 3, 3714-3718 (2009).


Li et al. synthesized high quality polyaniline nanofibers by a rapid polymerization of aniline using ammonium peroxydisulfate (APS)/Fe²⁺ redox initiator as the oxidant without any hard or soft templates. Polymer 51, 1934-1939 (2010).
Majority of work reported till date is not as simple as we are presenting here. The complex chemistry of polyaniline formation once again proved that there are lots more to do. To the first concern, we are here with a very simple route to prepare emeraldine base nanoparticles. The procedure is simple and discussed below:

1. Prepare the solutions of aniline and oxidant in aqueous solution of an inorganic acid.
2. Cool these solutions at a predetermined temperature.
3. Pour the oxidant solution into the aniline solution and keep it undisturbed for overnight at the predetermined temperature.
4. Separate polyaniline by filtration with a Buckner funnel.
5. Convert green emeraldine salt into emeraldine base nanopowder by dedoping by a predetermined dedoping agent.

The nanopowder was analyzed for FTIR (Figure-1) and TEM (Figure-2). Moreover, a flow diagram of complete procedure is given in Figure-3.
We Claim,

1. A technique for the production of polyaniline nanoparticles comprising following steps:
   a). Acidic aqueous solution of aniline of predetermined concentration is made.
   b). Acidic aqueous solution of potassium persulphate of predetermined concentration is also made.
   c). The two solutions were allowed to cool at a predetermined temperature.
   d). Predetermined volume of potassium persulphate solutions is gently poured into the equal volume of the aniline solution in glass beaker and kept at the predetermined temperature for overnight (normally more than 14-15 hours). The polymer so obtained was filtered, washed with distilled water, dedoped with excess of predetermined dedoping agent followed by washing with distilled water and dried in air oven.

2. A technique for the production of polyaniline nanoparticles (emeraldine base) claimed in claim 1 wherein the mixture is not stirred/agitated by any means.

3. A technique for the production of polyaniline nanoparticles claimed in claim 1 and claim 2 wherein there is no special control is required.

4. A technique for the production of polyaniline nanoparticles claimed in claim 1, 2 and 3 wherein the developed polyaniline nanoparticles are separated from mother liquor by Buckner funnel.

5. A technique for the production of polyaniline nanoparticles claimed in claim 1, 2, 3 and 4 wherein the technique described with reference to the accompanying drawing (Figure-3).

Applicants

1. Faiz Mohammad
2. Shahid Pervez Ansari

Dated this day of October, 2010
ABSTRACT
The invention relates to a technique for producing emeraldine base nanoparticles wherein predetermined volumes of aniline and oxidant solutions in aqueous inorganic acid is maintained at a predetermined temperature. Predetermined volume of the oxidant solution is gently poured into the equal volume of aniline solution. The reaction mixture is kept undisturbed at predetermined temperature for overnight. The emeraldine salt is separated over a Buckner funnel and dedoped by excess of predetermined dedoping agent followed by washing with double distilled water and drying at 60°C in air oven for 2 days.
Figure-1. FTIR spectrum of emeraldine base nanoparticles performed in KBr disc.

Figure 2. TEM image of emeraldine base nanoparticles.
Figure 3. Flow diagram for preparation of emeraldine base nanoparticles.

Acknowledgements

Authors are very thankful for the TEM facility extended to us by SAIF (DST), Department of Anatomy, AIIMS, New Delhi.
Annexure-2
C.B.R. NO.: 642
To: DR. FAZ MOHAMMAD
DEPARTMENT OF APPLIED CHEMISTRY, ALIGARH MUJIB UNIVERSITY, ALIGARH-202002, INDIA.

Date/Time: 31-01-2008 12:34:18

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A2-1
THE PATENT ACT, 1970

COMPLETE SPECIFICATION

SECTION 10

“PRODUCTION OF ZINC OXIDE NANOPARITCLES AT ATMOSPHERIC PRESSURE AND LOW TEMPERATURE”

Akhtar Husain Ansari, an Indian national of University Polytechnic, Aligarh Muslim University, Aligarh-202002, India.

Faiz Mohammad, an Indian national of Department of Applied Chemistry, Aligarh Muslim University, Aligarh-202002, India.

Shahid Pervez Ansari, an Indian national of Department of Applied Chemistry, Aligarh Muslim University, Aligarh-202002, India.
The following specification particularly describes and ascertains the nature of this invention and the manner in which it is to be performed.

The present invention relates to a procedure of “production of zinc oxide nanoparticles at atmospheric pressure and low temperature”.

BACKGROUND:

Research in the field of nano sized materials has increased enormously during past years. Nanomaterials are exciting subject in the fields of both fundamental study and applied sciences. The novel optical, electrical and mechanical properties of devices comprising nanocrystalline semiconductors and oxides have been demonstrated in photovoltaic solar cells, light emitting diodes, electrochromic devices etc.

There has been a great deal of interest in zinc oxide, it has many industrial applications owing to its piezoelectric properties and band gap in near ultraviolet region (band gap energy $E_g = 3.37$ eV and excitation banding energy of 60 meV). Zinc oxide is technologically important material that produces an efficient blue-green luminescence and displays excitonic ultraviolet (UV) laser action at room temperature. It is one of the few oxides that show quantum confinement effects in experimentally accessible particle size range.

In nano structured zinc oxide the small length scale and larger surface area to volume ratio means that surface defects play a stronger role in controlling properties as electronic processes are strongly influenced by surface processes.

Nano zinc oxide is one of the multifunctional inorganic nanoparticles possesses many significant physical and chemical properties such as chemical stability, low dielectric constant, large electromechanical coupling coefficient, high luminous transmittance, high catalytic activity, intrinsic ultraviolet and infrared absorption etc. As a result, zinc oxide nanoparticles can be used as/in catalysts, gas sensors, field emission displays, piezoelectric devices, UV shielding materials etc.

Zinc oxide nanostructures have high sensitivity even at room temperature where as thin film gas sensors often used to be operated at elevated temperature.
Recently, zinc oxide has been used in dye sensitized solar cells as an electrode material.

There are numerous ways of producing zinc oxide particles of various sizes and the process conditions vary from high temperature (above 1000°C) and high pressure (above atmospheric pressure) to low temperature and atmospheric pressure. The production of zinc oxide nanoparticles by reported methods requires sophisticated tools and equipments and reaction time is also a considerable factor. The present technique produces zinc oxide nanoparticles at atmospheric pressure and the temperature below the boiling point of water. Therefore, it does not need sophisticated installation for production of zinc oxide nanoparticles.

There are a number of disadvantages associated with the already existing techniques of manufacturing zinc oxide nanoparticles.

Gerhard Wegner et. al. [1] used wet chemical route to produce zinc oxide nanocrystals of monodisperse size distribution (diameter range from 20 nm to 80 nm) of ellipsoidal shape. In this process, zinc acetate dehydrate was converted to zinc oxide in presence of 1-propanol in m-xylene at 130°C for 2 hours. While p-toluene sulphonylic acid was used as catalyst. The main problems of this route are organic nature of reaction mixture, high temperature and long reaction time.

David Diaz et. al. [2] presented a pathway to synthesize zinc oxide nanoparticles with a narrow size distribution. The synthesis involves the simple dissolution of zinc carboxylate hydrated salts such as zinc cyclohexabutyrate and zinc acetate in aprotic solvents such as dimethylsulphoxide and N, N’-dimethylformamide at room temperature. In this procedure, the hydrolysis of zinc carboxylate salts was carried out in a very controlled environment with 3% water content in reaction mixture. This is a very serious problem to this procedure as it is difficult to maintain the above water content in reaction mixture because of hygroscopic nature of solvents used.

Daren Yang et. al. [3] used hydrothermal route to produce flower like zinc oxide nanostructures which consisted of sword like zinc oxide nanorods from cetyltrimethyl ammonium bromide at 120°C. To maintain a high temperature condition like 120°C for period of 20 hours is very difficult. Normally for this purpose autoclave is used and pressure is approximately 15 lb/in² at 120°C.
Peter C. Searson et. al. [4] produced zinc oxide nanoparticles by precipitation from 2-propanol. A reaction of zinc acetate and sodium hydroxide was carried out in 2-propanol and octanethiol was used to quench particle growth. Organic nature of reaction medium and reaction time of about 4 hours are main problems in this procedure.

Angela Agostiano et. al. [5] reported a non-hydrolytic route to prepare zinc oxide nanoparticles by means of thermal decomposition of zinc acetate (anhydrous) in alkylamine in presence of tert-butylphosphonic acid. Organic nature of reaction medium, High temperature 230°C and degassing of reaction mixture under vacuum for 1 hour under vigorous stirring with a controlled heating rate are some problems with this method which require sophisticated equipments.

Shinobu Fujihara et. al. [6] prepared zinc oxide nanocrystalline particles from alcoholic solution of zinc acetate dihydrate without using base. In this procedure, alcoholic solution of zinc acetate dihydrate was first ultrasonicated for 10 minutes and after addition of water to it, it was again ultrasonicated for another 10 minutes followed by reflux at 60°C for 12 hours. Organic nature of reaction medium, long reaction time and use of sophisticated equipment for ultrasonication of reaction mixture are some problems of this procedure.

Vaerie Briois et. al. [7] presented a two step procedure for preparation of zinc oxide nanoparticles. In this process, firstly they produced precursor followed by its hydrolysis to form colloidal particles. The zinc precursor was prepared by dissolving zinc acetate dihydrate in absolute ethanol, refluxed at 80°C for 3 hours. This precursor was then hydrolysed by lithium hydroxide at various temperatures. The drawbacks of this procedure are the use of absolute ethanol, long duration of reaction and the involvement of two steps in the procedure.

Tetsuo Kawano and Hiroaki Imai [8] presented aqueous route for synthesis of zinc oxide nanoparticles. In this process they obtained zinc oxide nanoparticles by two routes namely acidic and basic route at 60°C for two hours. The process demonstrated by them requires flow rate control for the reactants and moreover the reaction is two hour reaction.
In all the above reported works, it has been observed that earlier experiments were either carried in organic media with some catalyst and co-catalyst or if the reaction were carried in water the procedure is time consuming and used sophisticated instrumentation.

We present a simple mixing process to prepare zinc oxide nanoparticles. Our procedure is simple in following terms:

- We present a process to produce zinc oxide nanoparticles which employ water as a reaction medium.
- We present a process to produce zinc oxide nanoparticles where capital investment is very low.
- We present a process to produce zinc oxide nanoparticles where the reaction is completed in minutes.
- We present a process to produce zinc oxide nanoparticles in which the reaction is carried out at a temperature as low as 70°C and even less.
- We present a process to produce zinc oxide nanoparticles where the reaction takes place at atmospheric and controlled baric pressure is completely eliminated.

The objective of present invention is to develop a cheap, easy, less time consuming and environmental friendly technique to produce zinc oxide nanoparticles. In addition to this, the present invention provides pollution free technique.

To achieve the said objectives the invention provides a technique shown in Figure-1 (Page.14) and Figure-2 (Page.15).

We Claim,

1. A technique for the production of zinc oxide nanoparticles comprising:
Aqueous solution of zinc acetate dihydrate of predetermined concentration is made.
Aqueous solution of sodium hydroxide of predetermined concentration is also made.
Aqueous solution of surfactant of predetermined concentration is made.

Predetermined volume of the zinc acetate dihydrate solution taken in container. It is kept on stirring by any known stirring method. Secondly, the temperature of the solution is maintained at a predetermined level of temperature below the boiling point of water.

Predetermined volume of surfactant solution is added/not added to the solution.
Predetermined volume of the basic solution(sodium hydroxide) is added to the mixture.

Then the mixture is allowed to develop zinc oxide nanoparticles.

2. A technique for the production of zinc oxide nanoparticles claimed in claim 1 wherein the mixture is stirred uninterruptedly for a predetermined period of time and the reaction is allowed to complete.

3. A technique for the production of zinc oxide nanoparticles claimed in claim 1 and claim 2 wherein the predetermined period of time for the completion of reaction should be sufficient for the nucleation of the particles and their growth to the predetermined size.

4. A technique for the production of zinc oxide nanoparticles claimed in claim 1, 2 and 3 wherein the developed zinc oxide nanoparticles are separated by a known method of separation.
5. A technique for the production of zinc oxide nanoparticles claimed in claim 1, claim 2, claim 3 and claim 4 wherein the technique is described with reference to the accompanying drawings (figures 1 and 2).

Applicants
1. Akhtar Husain Ansari
2. Faiz Mohammad

Dated this 29th day of January, 2008
ABSTRACT
The invention relates to a technique for producing nanoparticles of zinc oxide wherein predetermined volume of predetermined concentration of zinc acetate dihydrate solution in distilled (doubly) water is maintained at a predetermined temperature. The solution is kept in motion by any known method. Predetermined volume of aqueous solution of known surfactant is added/ not added to the solution. Predetermined volume of any known basic aqueous solution is added to the reaction mixture. The reaction takes place in the mixture and colloidal solution of zinc oxide particles is formed. Sufficient time is given for the completion of reaction. After the completion of the reaction the mixture is given a predetermined time, so that zinc oxide particles can grow. Zinc oxide nanoparticles are separated by a known method.
REFERENCES


Abstract: A wet-chemical method to produce zinc oxide nanocrystals of monodisperse size distribution (diameter range of 20 nm to 80 nm) in presented. The synthesis starts from zinc acetate dehydrate which is converted to ZnO in the presence of 1-propenol in m-xylene at 130°C. We report for the first time catalysis of the reaction by p-toluene sulphonie acid monohydrate (p-TSA), which allows a shorter reaction time and improves both the reproducibility of the particle size distribution and the crytallinity of the particles. The reaction can be scaled up to give multigram quantities of product per batch. Particles were characterized by X-ray diffractometry (XRD), scanning electron microscopy (SEM), high resolution transmission electron microscopy (HRTEM), and photoluminescence (PL) spectroscopy. Room temperature PL spectra of ZnO prepared without catalyst exhibit a strong and sharp UV emission band at ca. 385 nm and a weak and very broad green-yellow visible emission centered at ca. 550-560 nm. However, for nanoparticles precipitated in the presence of p-TSA, the UV emission is enhanced by a factor of 4, which can be correlated with the improvement of crystal perfection. A particle formation mechanism is discussed.


Abstract: A novel and easy synthesis pathway to synthesize small ZnO nanoparticles with a narrow size distribution is reported. The synthesis implies the simple dissolution of a zinc carboxylate hydrated salt (cyclohexanebutyrate or acetate) in a polar basic aprotic solvent as dimethyl sulfoxide (DMSO) or N,N'-dimethylformamide (DMF) at room temperature. It is necessary to control the water content and temperature to ensure the reproducibility. The hydrolysis of
zinc carboxylates allows the formation of ZnO nanoparticles of different sizes, depending on reaction conditions. Solvent basicity and the interaction of DMSO-H₂O play crucial roles on the hydrolysis mechanism. The stability and the optical properties of the ZnO colloids were monitored by UV-visible electronic absorption and emission spectroscopies. From an HR-TEM study it was established that low concentration (2 × 10⁻⁴ M) of zinc cyclohexanebutyrate and zinc acetate afforded ZnO nanocrystallites of (2.12 nm, SD = 0.76) and (3.0 nm, SD = 0.5), average size, respectively. ZnO nanocrystals with rock salt structure coexist with wurtzite structure when zinc cyclohexanebutyrate is used as the starting salt. Dynamic light backscattering size measurements of ZnO nanoparticles were accomplished in DMSO colloid dispersions, resulting in the detection of small individual nanoparticles and assemblies of nanoparticles. Powder X-ray diffraction spectroscopy was used to accomplish the nanoparticle characterization, of DMF dispersions. Experimental results show that cyclohexanebutyrate acts as a more effective capping agent than acetate. Low concentration (2 × 10⁻⁴ M) colloidal ZnO dispersions in DMSO did not show any flocculation or red shift in two months, probably due to the concatenated dynamic stabilizing action of carboxylate ions and solvent molecules. The ZnO colloids in DMF are not stable and readily precipitate; moreover, nanoparticles in this solvent tend to adhere to glass walls, which allow production of ZnO films.


Abstract: The flowerlike ZnO nanostructures, which consisted of swordlike ZnO nanorods, have been prepared by a cetyltrimethylammonium bromide (CTAB)-assisted hydrothermal process at low temperature (120 °C). The XRD pattern indicated that the flowerlike ZnO nanostructures were hexagonal. Furthermore, the SAED and HRTEM revealed that the swordlike ZnO nanorods were single crystal in nature and preferentially grew up along [001]. Finally, the mechanism for the CTAB-assisted hydrothermal synthesis of flowerlike ZnO nanostructures has been preliminarily explained by polar crystal growth theory and surfactant action theory.
4. Quenching of Growth of ZnO Nanoparticles by Adsorption of Octanethiol.
Noshir S. Pesika, Zeshan Hu, Kathleen J. Stebe, and Peter C. Searson*.

Abstract: To exploit the size dependent properties of nanoparticles, it is essential
to control the particle size. We show that injection of octanethiol into suspensions
of ZnO particles can be used to quench particle growth. X-ray photoelectron
spectroscopy studies of the adsorption of octanethiol on ZnO single crystals
indicate relatively weak adsorption of thiolate and sulfonate species dependent on
the crystal orientation. These results suggest that adsorption of thiolate and
sulfonate groups on ZnO particles in suspension prevent dissolution of the solid
phase. Furthermore, the octanethiol is adsorbed sufficiently strongly to quench
growth but can be easily removed for subsequent surface functionalization.

5. ZnO Nanocrystals by a Non-hydrolytic Route: Synthesis and
Characterization. P. Davide Cozzoli, M. Lucia Curri, and Angela Agostiano*,

Abstract: We report a novel, non-hydrolytic route to ZnO nanocrystals by means
of thermal decomposition of zinc acetate (ZnAc$_2$) in alkylamines, in the presence
of tert-butylphosphonic acid (TBPA). The slow heating of an
alkylamine/TBPA/ZnAc$_2$ mixture is a simple, safe, and scalable approach to
synthesize ZnO nanocrystals from handy chemicals. The obtained ZnO
nanocrystals were characterized by UV-vis absorption, photoluminescence (PL)
and infrared (FT-IR) spectroscopies, and by X-ray diffraction (XRD) and
transmission electron microscopy (TEM). The growth of ZnO particles in the
nanoscopic regime and their final size were governed by the TBPA/ZnAc$_2$ molar
ratio in the reaction mixtures. The various roles played by TBPA in the conditions
of the synthesis are discussed on the basis of the experimental evidence. The
presented synthetic approach provides a unique tool for designing the synthesis of
ZnO crystals of a desired size in the nanoscale regime and can be potentially
extended to other nanoscale materials.

Abstract: Nanocrystalline ZnO particles were prepared from alcoholic solutions of zinc acetate dihydrate without using base such as NaOH or LiOH through a colloid process carried out at a low temperature of 60°C. A comparative study of chemical reactions from zinc acetate dihydrate to ZnO was made using different types of monool solvents, i.e. methanol, ethanol, and 2-methoxyethanol. It was revealed that layered hydroxide zinc acetate was formed as an intermediate and its transformation into ZnO was a key reaction step in any of the solutions. Reaction time necessary for the precipitation of ZnO was greatly influenced by the solvents used. Methanol was useful for the preparation of the ZnO nanoparticles, which were chemically pure in terms of cation impurities and exhibited green photoluminescence by the ultraviolet excitation.


Abstract: The chemical and structural nature of powders prepared from the zinc acetate-derived precursor using the sol-gel route is discussed. The influence of the synthesis temperature and of the hydrolytic catalyst on the structural features of the powder is focused on the basis of X-ray powder diffraction (XRPD) and extended X-ray absorption fine structure (EXAFS) measurements and complemented with density and thermoanalysis (TG-DTA) results. EXAFS and XRPD results show that no-washed nanoparticulate powders are composed of a mixture of ZnO (wurtzite), zinc acetate, and zinc hydroxyacetate. The latter has a layered structure typical of hydroxy double salts (HDS). The main component of no-washed powders is always unreacted zinc acetate solid but the relative amount of the zinc-based compounds depends on the nature of the hydrolytic catalyst, hydrolysis ratio, and of synthesis temperature. According to the proportion of the three zinc-based compounds, three families of powders could be distinguished.
The amount of ZnO nanoparticles (1.6 ± 0.6 nm) decreases as the synthesis temperature increases, as the hydrolysis ratio decreases, or by changing from basic to acid catalysis. This finding suggests that the formation of zinc compounds is controlled by the equilibrium between hydrolysis-condensation and complexation-reprecipitation reactions.

8. Fabrication of ZnO Nanoparticles with Various Aspect Ratios Through Acidic And Basic Routes. Tetsuo Kawano and Hiroaki Imai*

Abstract: Nanoscale ZnO grains and rods having various aspect ratios were selectively synthesized through acidic and basic routes, respectively, in an aqueous system at 60°C. Equiaxial nanograins were obtained by the addition of NaOH into an acidic solution of ZnSO4 (acidic route). On the other hand, nanorods with an aspect ratio ~12 were prepared by the introduction of ZnSO4 into a basic solution of NaOH (basic route). The aspect ratio of ZnO nanoparticles was changed by the preparation routes, whereas the final pH of the solutions was the same. The variation of pH in the reaction system influenced the density of homogeneous nucleation and the crystal growth along the $c$ axis. The morphological control of one-dimensional ZnO particulate materials with nanosized diameters and lengths was successfully achieved using the simple mixing techniques.
Figure-1. Block diagram for the “Production of zinc oxide nanoparticles at atmospheric pressure and low temperature (without surfactant).
Figure-2. Block diagram for the “Production of zinc oxide nanoparticles at atmospheric pressure and low temperature (with surfactant).”
Annexure-3
HYDROSTATIC BEHAVIOUR OF REACTION MEDIUM ON THE SYNTHESIS OF ZINC OXIDE NANO PARTICLES

S. P. Ansari¹, A. H. Ansari² and F. Mohammad³

¹Department of Applied Chemistry, ²Mechanical Engineering Section
Aligarh Muslim University, Aligarh.

ABSTRACT

Fine powders of zinc oxide are conventionally used in paint formulations, cosmetics, catalysis and gas sensors. It is a promising material for optoelectronic devices also, for example, light emitting diodes, flat display screens and solar cells due to its wide band gap. These applications require well-defined crystals; therefore, the significance of its synthesis and characterization has increased incredibly in the recent years.

Numerous chemical strategies have been reported to synthesize micro and nano scale zinc oxide particles. Solvent-based process is the efficient and simple technique to synthesize well-defined crystals of zinc oxide. In the present paper, the effect of buoyancy offered by the solution in the growth of zinc oxide crystals is studied. Zinc acetate dihydrate and sodium hydroxide are used to synthesize zinc oxide crystals.

It was observed that buoyancy favors the growth of the zinc oxide crystals to a certain limit. Thus produced zinc oxide particles were characterized by FTIR and SEM. Mechanism of the growth of zinc oxide crystals favored by the buoyancy of solution is also discussed. The N-Cetyl-N,N,N-Trimethylammonium Bromide (CTAB) was observed to favor the directional growth of the crystals.

1. INTRODUCTION

Research in the field of nano sized materials has increased enormously during past some years. Nanomaterials is an exciting field, both for the fundamental study and the applied research. The novel optical, electrical and mechanical properties of devices comprising nanocrystalline semiconductors and oxides have been demonstrated in photovoltaic solar cells, light emitting diodes, electrochromic devices etc.

There has been a great deal of interest in zinc oxide owing to its piezoelectric properties and band gap in near ultraviolet region (Eg=3.37 eV and excitation binding energy of 60 meV) and thus has many industrial applications. Zinc oxide is a technologically important material because it produces an efficient blue-green luminescence and displays an excitonic ultraviolet (UV) laser action at room temperature. It is one of the few oxides that show quantum confinement effects in experimentally accessible particle size range. In nanoparticles of zinc oxide, the nanosize particles lead to a great increase in the surface area. Larger surface area means greater number of surface defects that play an important role in controlling the surface properties as the electronic processes are strongly influenced by surface properties. Nanoparticles of zinc oxide are one of the multifunctional inorganic nanoparticles that possess many significant physical and chemical properties such as chemical stability, low dielectric constant, large electromechanical coupling coefficient, high luminous transmittance, high catalytic activity, intrinsic ultraviolet and infrared absorption etc. As a result, zinc oxide nanoparticles can be used as in catalysts, gas sensors, field emission displays, piezoelectric devices, UV shielding materials etc. Zinc oxide nanoparticles have high sensitivity even at room temperature whereas thin film gas sensors often operate at elevated temperatures. Recently, zinc oxide has been used in dye sensitized solar cells as an electrode material.

There are numerous ways of producing zinc oxide particles of various sizes and the process conditions vary from high temperature (above 1000°C) and high pressure (above atmospheric pressure) to low temperature and atmospheric pressure. The production of zinc oxide nanoparticles by reported methods requires sophisticated equipments and the reaction time is also significantly longer. The technique proposed by Ansari et al. involves atmospheric pressure
and low temperature (below the boiling point of water) as well as it does not require any sophisticated equipments for the production of zinc oxide nanoparticles.

**EXPERIMENTAL**

Zinc acetate dihydrate, sodium hydroxide, N-cetyl-N,N,N-trimethylammonium bromide (CTAB) were purchased from CDH, India. All the chemicals were used as received without any further purification. Stock solutions of zinc acetate dihydrate [0.1M] (solution-A), sodium hydroxide [2M] (solution-B)7, CTAB8 [0.1 M] were prepared in double distilled water. 90 ml of double distilled water was taken in a conical flask and 5 ml of solution-A was added to it, followed by the addition of 5 ml of solution-B. The mixture was heated to 70°C with vigorous stirring for 15 min and then kept undisturbed for a determined period of time. The reaction was carried in absence CTAB as well as in presence of CTAB for its different concentrations. The precipitates were separated, washed with double distilled water and acetone and then dried for 1hr.

**RESULTS AND DISCUSSION**

It is well known that elongated hexagonal zinc oxide crystals grow along the c-axis and has both the polar and non-polar surfaces. The non-polar crystal faces are more energy favorable and hence more stable than those that are polar.

In solution, growth units could deposit on to zinc oxide nanoparticles from all the directions and stacked on each crystal face. The reaction intermediates decompose into zinc oxide nanoparticles as the reaction proceeds and serve as seedling for the further deposition leading to the growth of the particles9.

There is an important distinction to be made between aqueous solution deposition of zinc oxide (thin film/precipitate) from open and closed baths, the latter conditions lead to the hydrothermal process. In general, the solubility of zinc oxide is greater under hydrothermal conditions and thus growth is typically slower10. In the present paper, the effect of reaction medium on the formation of zinc oxide nanoparticles is studied while the water is used as the reaction medium.

In our experiment, when the concentrations of Zn²⁺ and OH⁻ reach the saturation point, zinc oxide nuclei are formed according to the following equation.

(\(\text{Zn}^{2+} + \text{OH}^-\rightarrow \text{Zn(OH)}_2\))

In solution phase synthesis, processes like coarsening and aggregation can compete with nucleation and growth of the nanoparticles and play a crucial role in modifying the particle size distribution in the system. According to Lifshitz-Slyozov-Wagner model, the rate of coarsening is given by the equation:

\[(r)^2 - (r_0)^2 = kt\]

where \(r\) is the average particle radius, \(r_0\) is the initial particle radius, \(t\) is the time and \(k\) is the rate constant. The rate constant is dependent on the molar volume of the solid phase, the surface energy, the bulk solubility and the diffusion coefficient for metal ions in the solution11.

Fig. 1 shows the FTIR spectrum of the zinc oxide particles prepared by this process. The absorption peak at 1589 cm⁻¹ and 1408 cm⁻¹ are assigned to surface adsorbed carboxylate anions which are chemisorbed on surface of the zinc oxide particles. The peak at 480 cm⁻¹ is assigned to Zn-O bond. The bands observed at 905 and 3378 cm⁻¹ are associated with characteristic vibrations of -OH group adsorbed on the surface of the zinc oxide particles12.

The morphology of thus prepared zinc oxide particles was characterized by SEM and the typical images are shown in Fig. 2(i)-(iii). It was observed that when solution was given sufficient time (24 hrs), the particles grew and settled down at the base of the flask. It was due to the fact that the weight of the particles exceeded the buoyancy of the solution. For floating bodies, the weight of the body should be less than the buoyancy of the fluid. The particles were separated through filtration process. However, when the time for coarsening was reduced to a maximum of 0.5 hrs, the hazing of the reaction mixture got reduced but the settlement of some particles was observed. TABLE-1 gives a detailed idea of preparation parameters at a glance.

**TABLE 1.** Preparation parameters of zinc oxide nanoparticles.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Reaction Medium</th>
<th>Growth Period</th>
<th>Shape Size</th>
<th>Particle Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fig. 2 (i)</td>
<td>Water</td>
<td>24 hrs</td>
<td>Flowerlike</td>
<td>300-500 nm</td>
</tr>
<tr>
<td>Fig. 2 (ii)</td>
<td>Water</td>
<td>0.5 hrs</td>
<td>Flowerlike</td>
<td>180-300 nm</td>
</tr>
<tr>
<td>Fig. 2 (iii)</td>
<td>Aqueous CTAB (0.01M)</td>
<td>24 hrs</td>
<td>Rod</td>
<td>Dia-200-300 nm</td>
</tr>
</tbody>
</table>

This indicates that few particles undergo coarsening and settle down because of their larger size by overcoming the buoyant force of the reaction mixture. But during the shorter period experiment, a good number of particles remained suspended in the solution because of their small size. When the growth period was reduced to much short (~1-2 min.), no particle settlement was observed. Such particles could not be separated by filtration. It infers that smaller particles, more precisely particle in nanometer
HYDROSTATIC BEHAVIOUR OF REACTION MEDIUM ON THE SYNTHESIS OF ZINC OXIDE NANO PARTICLES

domain, could not overcome the buoyancy of reaction mixture and remained suspended in the solution. These smaller particles were separated by centrifuge. We have discussed this forced separation of particles in our second communication.

![Fig. 1 FTIR spectrum of zinc oxide prepared without surfactant.](image1)

**Fig. 1** FTIR spectrum of zinc oxide prepared without surfactant.

![Fig. 2 (i) Morphology of zinc oxide particles prepared without surfactant after 24 hrs growth period.](image2)

**Fig. 2 (i)** Morphology of zinc oxide particles prepared without surfactant after 24 hrs growth period.

![Fig. 2 (ii) Morphology of zinc oxide particles prepared without surfactant after 0.5 hrs growth period.](image3)

**Fig. 2 (ii)** Morphology of zinc oxide particles prepared without surfactant after 0.5 hrs growth period.

**CONCLUSIONS**

The particles of zinc oxide are formed when zinc acetate dihydrate and sodium hydroxide are allowed to react in open atmosphere at 70°C. The particles diffuse in the solution after the formation and segregate to grow. The buoyancy helps the growth of the particles to a certain limit till the buoyancy of solvent obeys the laws of floating bodies. When the size of particle exceeds the buoyancy force the particles sink and growth of the particles ceases. To minimize the size of particles, the buoyancy of the solution should be reduced. Therefore, dilute solutions will help the formation of nanoparticles.

**REFERENCES**


HYDROSTATIC BEHAVIOUR OF REACTION MEDIUM ON THE SYNTHESIS OF ZINC OXIDE NANO PARTICLES

Annexure-4
Electrical Studies on the Composite of Polyaniline with Zinc Oxide Nanoparticles

Shahid Pervez Ansari\(^1\) and Faiz Mohammad\(^2\)

\(^1\) Research Scholar, Department of Applied Chemistry, Faculty of Engineering & Technology, Aligarh Muslim University, Aligarh, India-202002, Email: shahidzahir@rediffmail.com

\(^2\) Professor, Department of Applied Chemistry, Faculty of Engineering & Technology, Aligarh Muslim University, Aligarh, India-202002, Email: faizmohammad54@rediffmail.com

Abstract

Inorganic-organic composites of polyaniline (PANI) with zinc oxide nanoparticles as inorganic filler are prepared by solution casting method using N-methyl-2-pyrrolidone as solvent. These composites are studied for their electrical conductivity and stability in terms of DC electrical conductivity retention using four-in-line probe technique under isothermal and cyclic heating of the test samples. The composites are also characterized by FTIR spectroscopy. It has been found that in composites there exist two conduction phases, as electrical conductivity first decreases with decrease in concentration of PANI. However, with the increase in concentration of ZnO nanoparticles, further the electrical conductivity of the composites increases. All the samples follow Arrhenius equation for the temperature dependence of electrical conductivity and support the semi-conducting nature of the doped state. The conductivity of the as prepared composites is found to be in semi-conducting region. The studied samples showed good electrical conductivity stability upto the temperature of 90°C.

Keywords: Polyaniline, Zinc oxide Nanoparticles, DC Electrical Conductivity, Stability.

1. Introduction

Mutual interactions between inorganic semiconductors and conducting polymers may give rise to interesting properties which are significantly different from that of individual components (Dutta et al., 2009). Nanostructures and nanocomposites of conducting polymers have emerged as a new field dedicated to the creation of smart materials for use in future
technologies (Malinauskas et al., 2005; Rajesh et al., 2009). Blending or encapsulation of inorganic nanoparticles in intrinsically conducting polymer matrix is believed to be easy route to prepare and design nanocomposites where delocalized π-electrons can interact with inorganic nanoparticles, resulting materials of unique or better properties (Lei and Su, 2007). Many studies on polymer nanocomposite preparation have been reported in quest to develop new advanced material with improved mechanical, electrical, optical and catalytic properties or to improve conduction mechanism in electronic devices. These materials have found their use in many electronic and nanoelectronic devices.

Polyaniline (PANI) is a promising conducting polymer due to its easy synthesis, environmental stability and high electrical conductivity on doping with protonic acids (Ahmed et al., 2004; Qiang et al., 2008). The preparation of PANI composites with various materials has received great attention because of their unique properties and applications in various electrical and electronic devices. Several reports dealing with the preparation of conducting composites such as: Fe3O4:PANI, MnO2:PANI, TiO2:PANI, ZrO2:PANI etc have been published (Yavuz and Gok, 2007; Gok et al., 2007), preparation and characterization of ZnO:PANI composites as well (Jeng et al., 2008; Paul et al., 2007 and Zhang 2009). However, in the present work, we have studied the electrical properties of the ZnO:PANI composites, based on ZnO nanoparticles as inorganic filler material and PANI as main matrix. We have studied the effect of ZnO nanoparticles on the electrical conductivity of the PANI and its thermal stability in terms of electrical conductivity retention in two slightly different conditions.

2. Experimental

2.1. Materials

The materials used include acetone (merck, India), ammonia (Qualigen, India), aniline (merck, India), hydrochloric acid (Rankem, India), potassium persulphate (CDH, India), N-methyl-2-pyrrolidone (Qualigen, India) and zinc oxide nanoparticles (avg. size 50 nm) (mknano, Canada) (Figure. 1). Aniline was doubly distilled before use and all other chemicals were used as received.
2.2. Preparation of PANI

Polyaniline (PANI) was obtained via oxidative polymerization of aniline in aqueous HCl (1M) solution. The oxidative polymerization of aniline in HCl (1M) was performed using potassium persulphate (K$_2$S$_2$O$_8$) as oxidant in HCl (1M) (Khatoon et al., 2008). The optimum ratio of aniline: oxidant (2:1) (Luzny et al., 2002) was kept constant during the reaction. Equal volume of 0.2 M aniline in HCl (1M) and 0.1M potassium persulphate (K$_2$S$_2$O$_8$) in HCl (1M) were separately cooled to 0-5 °C in refrigerator; the two solutions were mixed and kept undisturbed for overnight in refrigerator to complete polymerization. Next day, PANI (Emeraldine Salt) obtained was filtered and washed with double distilled water till filtrate was neutral to pH paper followed by its dedoping using 1M ammonia solution. It was again washed with double distilled water to get emeraldine base form of PANI, which after drying at 60°C in air oven for 2 days, was kept in dessicator for further studies (Khatoon, 2006; Ahmed, 2003).

2.3. Preparation of composites

Firstly, zinc oxide nanoparticles (ZnO) (10, 20, 30 mg) were dispersed in 50 ml of N-methyl-2-pyrrolidone (NMP) in round bottom flasks for 12 hrs. with continuous vigorous stirring at...
room temperature (Patil and Radhakrishnana, 2006; Zhang et al., 2009). In other flasks, polyaniline (PANI) base form (EB) (990, 980, 970 mg) were dissolved slowly with continuous stirring. Dispersion of ZnO nanoparticles were then added to PANI solution at a rate of 1ml/min. The films of the prepared composites were obtained by solvent evaporation method at 100°C in an air oven. Thus, prepared films were cut into small pieces of rectangular shape and subjected to a pressure of 10 tons using electrically operated hydraulic press machine at 150°C to get smooth films. Finally, we prepared films of pure PANI, PANI:ZnO (1%), PANI:ZnO (2%) and PANI:ZnO (3%). These films were then treated with 1M HCl for 24 hrs, washed with double distilled water repeatedly to remove traces of acid, dried at 60°C for 12 hrs. and were used for electrical studies.

2.4. Characterization

The pure PANI and composites of different composition of PANI were characterized by FTIR, DC electrical conductivity of HCl doped PANI and composite films were measured with increasing temperature (40 °C -150 °C) by using four-in-line probe DC Electrical Conductivity Measuring Instrument (Scientific Equipment, Roorkee, India). DC electrical conductivity (σ) was calculated using following equations:

\[ \rho = \rho^0 / [G_7(W/S)] \]  
\[ G_7(W/S) = (2S/W) \ln(2) \]  
\[ \rho^0 = (V/I) (2\pi S) \]  
\[ \sigma = 1/ \rho \]

Where \( G_7(W/S) \) is a correction divisor (which is a function of thickness of the sample as well as probe spacing) while I, V, W and S are current (A), voltage (V), thickness of the film (cm) and probe spacing (cm) respectively.

3. Result and Discussion

The size of zinc oxide nanoparticles may be observed in Figure.1, which supports the claim of its average particles size. The broad peak ranging between 440 cm\(^{-1}\) to 550 cm\(^{-1}\) (Figure.2a) can be assigned to Zn-O group (Lü et al. 2007, An’lovar et al., 2008). FTIR spectrum of
prepared PANI (EB) form is presented in Figure 2b. The band corresponding to out of plane bending vibration of C-H bond of p-disubstituted benzene rings appears at 824 cm\(^{-1}\) (Ahmed 2003, Blinova et al., 2007; Kalasad et al., 2009 and Song et al., 2008). The bands corresponding to vibration mode of N=Q=N (quinoid) ring and stretching mode of C-N bond appear at 1150 cm\(^{-1}\) (Yan et al., 2007) and 1307 cm\(^{-1}\) respectively (Zhou et al., 2009). Band at 1582 cm\(^{-1}\) and 1496 cm\(^{-1}\) (Olad et al., 2008) are assigned to C=C stretching of quinoid and benzenoid rings respectively. In case of composite prepared using PANI:ZnO (3%) in NMP (Figure 2c) peaks at 1298, 1678, 2879 and 2951 cm\(^{-1}\) due to characteristic peaks of NMP (Lee et al., 2000). In the IR spectra of PANI:ZnO, the peaks of pure PANI, shifted to lower wavenumber, indicating that all of these chemical bonds were weakened whereas, Zn-O peak broadened. According to the results of FTIR, hybridization between ZnO and PANI molecules is expected which resulted in an intense interaction and the chemical-adsorbed monolayer PANI structure caused an interface hybrid effect between PANI and ZnO (Zhang et al., 2009).

![Figure 2 FTIR spectra of (a) ZnO nanoparticle, (b) pure PANI (EB) and (c) PANI:ZnO (3%).](image)

The electrical conductivity of the composite films was measured from 40 °C to 150 °C and all were found in upper semi-conducting region. All the samples PANI and PANI:ZnO...
composites of different compositions followed Arrhenius plot for temperature dependence of electrical conductivity as seen in Figure.3 and suggest the semi-conducting nature of HCl doped composites. In case of pure PANI, highest electrical conductivity was observed as compared to the various composites. This support the fact that PANI is mainly responsible for electrical conduction and as its concentration decreased, a sharp decrease in conductivity was observed, however, with the increase in concentration of ZnO nanoparticles electrical conductivity increased. From the above observation it can be said that no doubt PANI is mainly responsible for the electrical conduction, presence of ZnO also contribute to conduction which is very much clear from (Figure. 3). In other two experiments, designed to study stability of electrical conductivity in atmospheric condition, results in support of above claims were found. Cyclic electrical conductivity study on these composites suggests that the electrical conductivity of the composites is more stable than simple PANI and with increase in ZnO content, increase in electrical conductivity stability is obtained (Figure. 4, 5, 6, 7). The isothermal electrical conductivity stability study reveals that the electrical conductivity is quite stable up to temperature 90 °C and with the increase in concentration of ZnO the stability increased and much better result was observed in case of composite containing PANI:ZnO (3%) as can be observed in Figure. 8, 9, 10, 11. Loss in electrical conductivity is because of the loss of dopants, chemical reaction of dopant with solvent and change in physical properties due to heat treatment (Zhang et al., 2009).

Figure.3. Arrhenius Plots of various composites and pure PANI.
Figure 4. Degradation of conductivity in terms of DC electrical conductivity retention for PANI by cyclic technique.

Figure 5. Degradation of conductivity in terms of DC electrical conductivity retention for PANI:ZnO (1%) composite by cyclic technique.
**Figure 6.** Degradation of conductivity in terms of DC electrical conductivity retention for PANI:ZnO (2%) composite by cyclic technique.

**Figure 7.** Degradation of conductivity in terms of DC electrical conductivity retention for PANI ZnO (3%) composite. by cyclic technique.
Figure 8. Degradation of conductivity in terms of DC electrical conductivity retention for PANI by isothermal technique.

Figure 9. Degradation of conductivity in terms of DC electrical conductivity retention for PANI:ZnO (1%) by isothermal technique.
Figure.10. Degradation of conductivity in terms of DC electrical conductivity retention for PANI:ZnO (2%) by isothermal technique.

Figure.11. Degradation of conductivity in terms of DC electrical conductivity retention for PANI:ZnO (3%) by isothermal technique.

4. Conclusions

We successfully prepared various stable composites PANI and ZnO nanoparticles. FTIR spectra of the samples support the interaction of PANI chain with ZnO, which cause thermal stability of the composites. Electrical conductivity study of the samples favors that PANI is
mainly responsible for the electrical conduction, however, little increase in conductivity was observed with increase in ZnO content and its effect is prominent in case of composite having 3% ZnO nanoparticles, thus shows the behavior of a composite of two differently conducting components as evident from Figure. 3. Cyclic and isothermal study reveals that loss of dopants and electrical conductivity has decreased with increased ZnO concentration, consequently, increased stability of the composites.

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References


Preparation and electrical studies on nanocomposite of polyaniline containing zinc oxide nanoparticles and polyacrylonitrile

Shahid Pervez Ansari and Faiz Mohammad*  
Polymer Research Laboratory, Department of Applied Chemistry,  
Faculty of Engineering & Technology, Aligarh Muslim University, Aligarh-202002.  
*Presenting Author’s E-mail: faizmohammad54@rediffmail.com

Abstract
Nanocomposites of polyaniline (PANI) with zinc oxide nanoparticles (ZnO) as inorganic filler and polyacrylonitrile (PAN) as supporting matrix have been prepared by solution method and studied for their electrical conductivity and for its stability in terms of conductivity retention using four-in-line probe DC electrical conductivity measurement method. The studies showed the electrical conductivity in upper semiconducting region. The isothermal and cyclic conductivity studies of the nanocomposites suggest good electrical conductivity stability below 100°C. It is observed that the electrical conductivity decreased with increase in zinc oxide content after a certain limit, however, the composite showed greater stability in terms of electrical conductivity retention. Thus prepared nanocomposites were also characterized using FTIR, TEM, TGA and XRD.

Figures- a) TEM image of Nanocomposite b) XRD spectrum of Nanocomposite.

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Studies on the composite of polyaniline with zinc oxide nanoparticles

Shahid Pervez Ansari and Faiz Mohammad*
Polymer Research Laboratory, Department of Applied Chemistry,
Faculty of Engineering & Technology, Aligarh Muslim University, Aligarh-202002.
*E-mail: faizmohammad54@rediffmail.com

Abstract
Polyaniline (PANI), a conducting polymer, and zinc oxide (ZnO), a metal oxide semiconductor, have attracted great attention of researchers because of their respective importance and applications. PANI was obtained by oxidative polymerization of aniline in acidic medium using potassium persulphate as oxidant. ZnO nanoparticles (n-ZnO) were used as purchased without any further treatment.

Composites of PANI:n-ZnO were prepared by solution mixing method in N-methyl-2-pyrrolidone and films were obtained by solvent evaporation method. Thus obtained films were acid doped by 1M HCl and studied for their electrical conductivity from 40°C - 150°C. DC electrical conductivity results supports that the conductivity of composites depends on both the fractions i.e. PANI as well as n-ZnO, present in composites. The decrease in conductivity due to decrease in PANI content is not equally compensated by increase in the n-ZnO content in the composites and thus shows the behavior of a composite of two differently conducting components.
Studies of Polyaniline: Polyacrylonitrile Composites Containing Zinc Oxide Nanoparticles

Shahid Pervez Ansari and Faiz Mohammad*
Department of Applied Chemistry
Faculty of Engineering & Technology
Aligarh Muslim University, Aligarh, India
*E-mail: faizmohammad54@rediffmail.com

Abstract
Polyaniline (PANI) was prepared by oxidative polymerization using potassium persulphate (K₂S₂O₈) as oxidant. Composites of polyaniline with polyacrylonitrile (PAN) and zinc oxide (ZnO) nanoparticles have been prepared by direct mechanical mixing process.

The composites (PANI:ZnO and PANI:ZnO) were studied for their electrical conductivity in temperature range 40°C-150°C and stability in isothermal condition were studied at temperatures 50°C, 70°C, 90°C, 110°C, 130°C using four-in-line probe DC electrical conductivity measuring instrument. The conductivity studies showed conductivity behavior of the samples in upper semi-conducting region and the isothermal studies show good stability in conductivity above 100°C also.

In the light of studies of the prepared composites possible applications can be proposed for various electrical and electronic devices and sensors will be proposed.
Nanomaterials: Materials for Future Technologies

Shahid Pervez Ansari, Mohd Omaish Ansari and Faiz Mohammad
Department of Applied Chemistry
Faculty of Engineering & Technology
Aligarh Muslim University
ALIGARH-202002 (India)
*E-mail: faizmohammad54@rediffmail.com

Abstract
When the size of a particle is less than a characteristic length scale, such as the diameter of an exciton or the mean free path of an electron, the properties of the particle can be significantly different from the bulk properties of the material. Such particles can be used as individual element in wide range of applications or can be assembled into devices. To exploit the size-dependent properties of particles for specific applications, it is essential to develop synthetic techniques that allow the control on the size of particles.

It is quite remarkable and very exciting indeed that we today have technologies that involve manipulation of the ultimate building blocks of the ordinary matter, single atoms or molecules. The control of the shape and the orientation of nanocrystallites as well as the ability to order them into larger three-dimensional arrays onto various types of substrates include the essential task to be done in order to create a generation of smart and functional materials for future technologies.

Nanotechnology deals with the natural and artificial structures on the nanometer scale i.e. in the range of 1µm down to 10Å. One nanometer (1 nm = 10⁻⁹ m) is roughly the distance from one end to the other, of a line of five neighboring atoms in ordinary solid. Nanotechnology owes it existence to the astonishing development within the field of microelectronics. Since the invention of the integrated circuit nearly half a century ago in 1958, there has been an exponential growth in the number of transistors per microchip and an associated decrease in the width of the wires in the electronic circuits. As a result, extremely powerful computers and efficient communication systems have emerged with a subsequent profound change in the daily lives of the human beings. A modern computer
chip contain more than 10 million transistors and the smallest wire width is incredibly small, now entering into <100 nm range. 

The technology is in early phase of development and expected to be widely applied and distributed. Typically, during this phase of the development of a new technology area, researchers focus mainly on identifying newer and newer properties and applications. Understanding the structure-function-application relationship that relates specifically to nanomaterials could led to the new “design rules” for producing benign, high-performance nanoscale substances and devices.