TOPIC OF THE PROJECT: VARIOUS CHEMICAL TECHNIQUES AND METHODS FOR SYNTHESIS OF SILVER NANOPARTICLES

Silver nanoparticles (NPs) or colloids have been extensively studied because of their potential applications in nano-medicine, nano-photonics and nano-devices. Traditionally nanoparticles were produced only by physical and chemical methods. Some of the commonly used physical and chemical methods are ion sputtering, solvothermal synthesis, reduction and sol-gel technique. Basically, there are two approaches for nanoparticle synthesis namely the bottom- Up and top down approach. In the top down approach, scientists try to formulate nanoparticles using larger ones to direct their assembly. The bottom-up approach is a process that builds towards larger and more complex system by starting at the molecular level and maintaining precise control of molecular structures. The most common approach for synthesis of silver nanoparticles is chemical reduction byorganic and inorganic reducing agents. In general, different reducing agents such as sodium citrate, ascorbate, sodium borohydride (NaBH4), elemental hydrogen, polyol process, Tollens reagent, N, N-dimethylformamide (DMF), and poly (ethylene glycol)-block copolymers are used for reduction of silver ions in aqueous or non-aqueous solutions. The presence of surfactants comprising functionalities (*e.g.*, thiols, amines, acids, and alcohols) for interactions with particle surfaces can stabilize particle growth, and protect particles from sedimentation, agglomeration, or losing their surface properties. Polymeric compounds such as poly (vinyl alcohol),poly(vinylpyrrolidone), poly (ethylene glycol), poly(methacrylic acid), and polymethylmethacrylate have been reported to be effective protective agents to stabilize nanoparticles. Various chemical techniques and method used for synthesizing silver nanoparticles are mentioned below:

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- **Micro-emulsion Teechniques**: Uniform and size controllable silver nanoparticles can be synthesized using micro-emulsion techniques. The nanoparticles preparation in two-phase aqueous organic systems is based on the initial spatial separation of reactants (metal precursor and reducing agent) in two immiscible phases. One of the major disadvantages of this method is the use of highly deleterious organic solvents. Thus large amounts of surfactant and organic solvent must be separated and removed from the final product.
- **UV-initiated Photoreduction**: A simple and effective method, UV-initiated photoreduction, has been reported for synthesis of silver nanoparticles in the presence ofcitrate, polyvinylpyrrolidone, poly(acrylic acid), and collagen. For instance, Huang and Yang produced silver nanoparticles via the photoreduction of silver nitrate in layered inorganic laponite claysuspensions which served as a stabilizing agent for the prevention ofnanoparticles aggregation. The properties of the produced nanoparticles were studied as a function of UV irradiation time.
- **Sonoelectrochemistry Technique:** Sonoelectrochemistry technique utilizes ultrasonic power primarily to manipulate the material mechanically. The pulsed sonoelectrochemical synthetic method involves alternating sonic and electric pulses, and electrolyte composition plays a crucial role in shape formation. It was reported that silver nanospheres could be prepared by sonoelectrochemical reduction using a complexing agent, nitrilotriacetate to aggregation .
- **Photo Induced Reduction Method**: Nano-sized silver particles with an average size of 8 nm were prepared by photo induced reduction using poly(styrene sulfonate)/poly(allylamine hydrochloride) polyelectrolyte capsules as microreactors. Moreover, it was demonstrated that

thephotoinduced method could be used for converting silver nanospheres into triangular silver nanocrystals (nanoprisms) with desired edge lengths in the range of 30-120 nm .

- **Electrochemical Synthetic Method**: Electrochemical synthetic method can be used to synthesize silver nanoparticles. It is possible to control particle size by adjusting the electrolysis parameters and to improve homogeneity of silver nanoparticles by changing the composition of the electrolytic solutions. Polyphenylpyrrole-coated silver nanospheroids (3-20 nm) were synthesized by electrochemical reduction at the liquid/liquid interface.
- **Irradiation Method**: Silver nanoparticles can be synthesized by using a variety of irradiation methods. Laser irradiation of an aqueous solution of silver salt and surfactant can produce silver nanoparticles with a well defined shape and size distribution. Furthermore, the laser was used in a photo-sensitization synthetic method of making silver nanoparticles using benzophenone .
- **Microwave Assisted Synthesis:** Microwave assisted synthesis is a promising method for the synthesis of silver nanoparticles. It was reported that silver nanoparticles could be synthesized by a microwave-assisted synthesis method employing carboxymethyl cellulose sodium as a reducing and stabilizing agent. The size of the resulting particles depended on the concentration of sodium carboxymethyl cellulose and silver nitrate. The produced nanoparticles were uniform and stable, and were stable at room temperature for 2 months without any visible change. The production of silver nanoparticles in the presence of Pt seeds, polyvinyl pyrrolidine and ethylene glycol was also reported by this method.