Evolution of AgX Nanowires into Ag Derivative Nano/microtubes for Highly Efficient Sunlight Photocatalysts

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Abstract

Sunlight-driven photocatalysts have been an attractive research field due to their high utilization efficiency for solar energy. To effectively use the visible light that comprises 43% of sunlight, efforts have been devoted to designing photocatalysts for high absorption coefficients in the visible and NIR regions. As a result, silver halide (AgX)/Ag nanocomposites have been recently developed and aare considered new visible light photocatalysts. Plasmonic nanoparticles (NPs) are more resistant to degradation and exhibit a high absorption coefficient in a broad visible-NIR range.[1-3] Our study proposes a novel strategy for the synthesis of Ag derivatives (AgX@Ag (X = Cl and Br) or Ag nano/microtubes) using the controlled chemical reduction or electron-beam irradiation of AgX nanowires (NWs), which were formed from the controlled dewetting of a AgX thin film on colloidal particles. The size of the AgX@Ag and Ag nano/microtubes can be controlled using the AgCl NWs as templates and varying the concentration of NaX. By controlling the concentration of NaBr, heterojunction-structured AgCl/AgBr NWs (H-AgCl/AgBr NWs) can be produced from the AgCl NWs due to a partial ion-exchange reaction (low concentration), and the AgBr NWs produced after a complete ion-exchange reaction between Cl- and Br- were further grown into micrometer-sized AgBr wires (high concentration). The resulting AgX NWs can be transformed into corresponding AgX@Ag or Ag nano/microtubes via a controlled chemical or physical method. The AgX derivatives (AgX@Ag nanotubes (NTs) and AgX NWs) were tested as visible-light-induced photocatalysts for decomposition of methyl orange. The AgX@Ag NTs exhibited the best photocatalytic activities due to the advantages of the core@shell structure, allowing multiple reflections of visible light within the interior cavity, providing a well-defined and clean Ag/AgX interface, and preventing direct adsorption of pollutants on AgX due to the shell structure. These advantages allow AgX@Ag NTs to maintain high catalytic performance even after multiple uses. The approach can also be used as a direct method for preparing Ag nano/microtubes with a tailored size and as a new method for incorporating a AgX NW core into a Ag nano/microtube shell. Our approach is useful for synthesizing various types of one-dimensional heterostructured NWs or metal NTs with controlled structures and properties.

References

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Figure

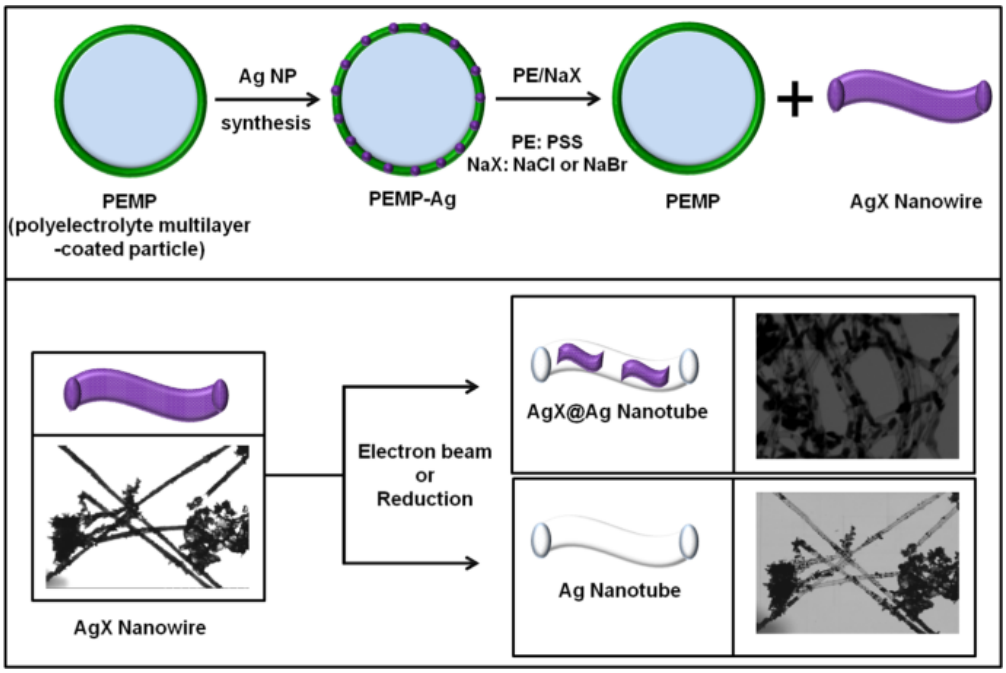

Figure 1. Schematic depiction of the synthesis of Ag derivatives (AgX@Ag (X = Cl and Br) or Ag nano/microtubes) using the controlled chemical reduction or electron-beam irradiation of AgX nanowires, which are formed from the controlled dewetting of a AgX thin film on colloidal particles. The AgX@Ag nanotubes are used as sunlight-driven photocatalysts.