A Facile Approach for Controlled Growth of Metal Oxide Films on Substrates irrespective of Hydrophilic or Hydrophobic Nature

Hye Jin Shin[1], Ha-Jin Lee[2], and Won San Choi[1,*]

[1]Department of Chemical and Biological Engineering, Hanbat National University, San 16-1, Dukmyoung dong, Yuseong-gu, Daejeon, 305-719, Republic of Korea, [2]Jeonju Center, Korea Basic Science Institute (KBSI), Dukjin-dong 1ga, Dukjin-gu, Jeonju, Republic of Korea

E-mail: choiws@hanbat.ac.kr; Fax: +82-42-821-1692; Tel: +82-42-821-1540

Abstract

The iron oxide (IO) nanoneedle film was prepared from hydrophilic or hydrophobic substrate: needlelike IO nanoparticles (NPs) were grown on the surface of the glass or tetrafluoroethylene (Teflon) substrate by the addition of a mixed aqueous Fe precursor solution to the solution involving substrates and controlled oxidation of the iron precursors under controlled conditions. The surface morphology of the IO film was determined by scanning electron microscopy. As illustrated in the figure, the substrate was uniformly covered with submicrometer-sized needlelike IOs. The length of the IO needles could be controlled by changing the incubation time or cycle of the iron precursor solution. As the reaction time was adjusted from 3 to 12 hours, the average length of the IO needles increased from 300 to 950 nm. Because the iron precursors were supplied to the substrate via surface diffusion in the aqueous environment, the shape of the IO needles sharpened as growth proceeded.[1-3] In the early stage of growth, the IO needles were sparsely distributed and thus laid parallel to the surface of the substrates. By comparison, as the growth proceeded, overcrowding of the IO needles led them to stand up, forming densely packed IO needles with high surface coverage. It is worth noting that the presence of the oxidant helped to activate the surface of substrates regardless of hydrophilic or hydrophobic nature, thus promoting the growth of IO nanoneedles with uniform distribution on any substrates. Even though the glass substrate has many reaction sites, such as negatively charged hydroxyl groups as well as defects, IO nanoneedles were not formed on the substrate in the absence of oxidant. Only in the presence of oxidant, positively charged iron precursors are more favorable for adsorption on the glass or Teflon substrate activated by oxidant. The presence of the IO species on the substrates after synthesis was confirmed by X-ray diffraction (XRD) and energy dispersive X-ray (EDX) analyses. The strong diffraction patterns in the XRD data confirmed that the synthesized IO needles were composed of goethite (a-FeOOH) and hematite (a-Fe_2O_3). After surface modification of IO nanoneedles, Ag NPs were synthesized onto IO nanoneedles. By appropriate treatment, it was possible to transform the Ag NPs into the Ag@AgX NPs on IO nanoneedles (Substrate/IO/Ag@AgCl). We expect that other metal oxide films can also be prepared and the resulting films can be utilized as a versatile film for environmental remediation. Our novel method described here is very useful for coating metal oxides on substrates irrespective of hydrophilic or hydrophobic nature.

References

[1] Won San Choi, Hye Young Koo, Jeong-Ho Park, Dong-Yu Kim, J. Am. Chem. Soc. (2005), 127, 16136-16142.
[2] Hye Young Koo, Ha-Jin Lee, Hye-Ah Go, Young Boo Lee, Tae Sung Bae, Jun Kyung Kim, Won San Choi, Chem. Eur. J. (2011), 17, 1214-1219.
[3] Won San Choi, Hye Young Koo, Dong-Yu Kim, Adv. Mater. (2007), 19, 451-455.

Figures

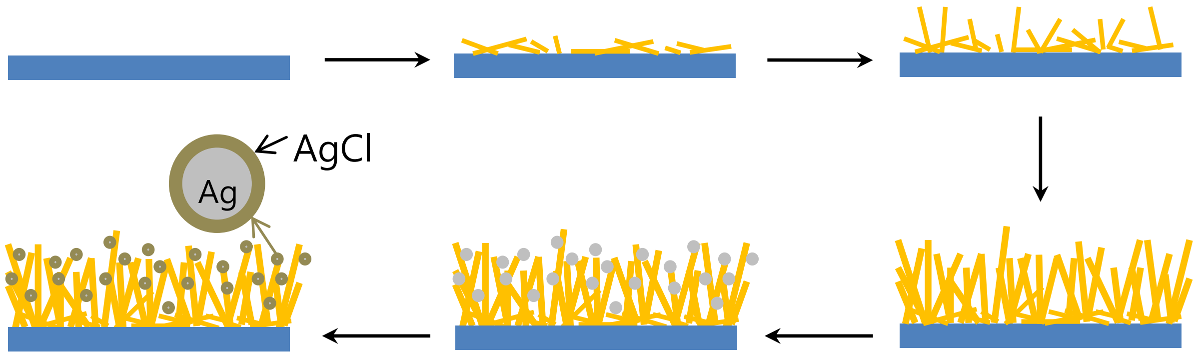

Figure 1. Schematic illustration for synthesis of the IO nanoneedle-like film decorated with Ag@AgCl NPs.