Industrial dye waste-water treatment by electrochemical catalytic process using TiO_2/ITO electrode

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Introduction

Textile industries have various processes. Among them, dyeing process uses large amount of water and the waste-water from dyeing process contains toxic wastes such as suspended solid, un-reacted dyestuffs and auxiliary chemicals that are used in dyeing process. Thus, many researchers investigated the waste-water treatment technologies such as physical, chemical, biological process. Researchers also studied advanced oxidation process like ozonation, photocatalytic oxidation [1-3], electrochemical oxidation [4], etc. Especially, photocatalytic oxidation has been widely studied. However, the photocatalytic process has not been applied to real textile waste-water treatment due to the inhibition of photocatalytic activity at low pH and difficulty in retrievement of photocatalyst.

Electrochemical process is an emerging technology for the treatment of waste-water because of its high efficiency and relatively simple system. We have developed the TiO_2/Indium_tin_oxide (ITO) electrode for the electrochemical system. Oxide conductor such as ITO has electrical and chemical stability compared to metal conductor. We also investigated the electrochemical oxidation process using TiO_2/ITO electrode for the industrial dye waste-water treatment. We found that the efficiency of electrochemical process using TiO_2/ITO electrode was sufficiently high for industrial dye waste-water treatment.

Materials and Methods

The electrochemical electrode was made by spin coating (3000rpm) of TiO_2 precursor solution. The precursor solution composed of titanium tetra-isopropoxide, acetylacetone and ethanol. Substrate was glass substrate which was coated by conducting ITO. After spin coating, the electrode was annealed at 550°C for 30min to remove organic components of precursor and crystallize to anatase TiO_2 phase. To perform electrochemical oxidation experiment, we designed electrochemical cell (Fig. 1(a)). The effective volume of the cell was 1600 cm^3 and the effective area of TiO_2/ITO electrode was 294 cm^2. Working electrode was TiO_2/ITO and counter electrode was Pt. For the experiment, real industrial dye waste-water was obtained from local textile industry. For comparison, we also made composite dye solution (50ppm) by mixing 6 kinds of dyes. (Reactive red 198, reactive black 5, acid blue 40, acid red 88, basic blue 54 and basic red 46) The degradation efficiency was measured by UV-Visible spectrophotometer.

Results and Discussion

Figure 1(a) shows the picture of electrochemical cell and DC power supply which were used in this experiment. Figure 1(b) shows the degradation efficiency for dye waste-water and composite dye solution. We applied +10V(1mA/cm^2) to the TiO_2/ITO electrode and measured the degradation efficiency with time. As a result, we found that 60% of textile dye waste-water and 85% composite dye solution were degraded only after 10 min. We thought that the fast degradation was attributed to the OH radical generation by direct electron tunneling to conduction band of TiO_2 semiconductor. The degradation rate of the dye waste-water, however, was lower (25%) than that of the composite dye solution due to the presence of suspended solid and auxiliary chemicals. On the other hand, 0.4% of the textile dye waste-water and 2.9% of the composite dye solution were degraded by the photocatalytic process. (UV illumination time = 10min, UV intensity = 54.4mW/cm^2, Distance between UV source and TiO_2/ITO electrode = 2cm). It is noteworthy that the degradation rate of electrochemical process was significantly high compared to that of the photocatalytic process. Therefore, we concluded that electrochemical process was much efficient compared to photochemical process. We also thought the electrochemical process using TiO_2/ITO electrode was suitable for the industrial waste-water treatment.

Significance

We developed practical dye waste-water treatment system by using TiO_2/ITO oxide electrode.

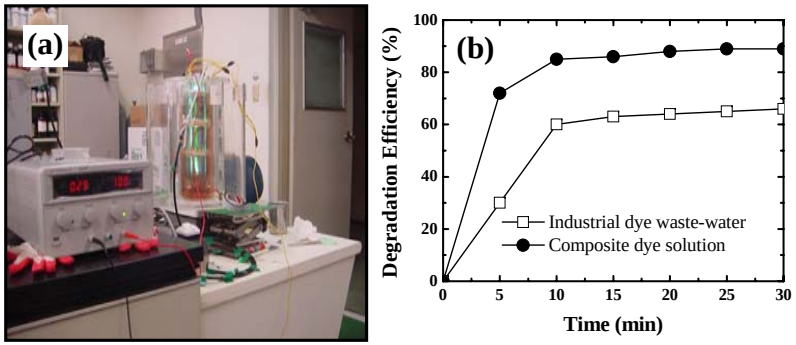

Figure 1. (a) Picture of electrochemical cell and DC power supply. (b) Degradation efficiency of industrial dye waste-water and composite dye solution. (V=10V (1mA/cm^2), @ 25°C)

References

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