Porous Polymer Frameworks (PPFs) for Antimicrobial Water Treatment

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Abstract*—New materials hold the key to fundamental advances in energy conversion, preventing water pollution and storage, all of which are vital in order to meet the challenges of global warming, pollutant in water and the finite nature of fossil fuels. Porous materials in particular offer unique properties or combinations of properties for such purposes. Water gets easily infected by bacterial activities under normal atmosphere and sunlight. Antibacterial activities of polymeric nano-materials present an opportunity for water disinfection. However, the nano-particles leach out of the polymer matrix resulting in the decrease of antimicrobial activity over time. In this regard, porous polymer frameworks (PPFs) containing cross-linked antimicrobial nano-particles prevent loss of nano-material. Thus, we prepared different PPFs with varying proportions of titania nano-particles to probe their effect on water disinfection. Finally, the thermal stability, morphological profile and antimicrobial activity of PPFs were enhanced by the increase of titania content.

***Keywords*—PPF's, antibacterial, titania, photocatalysis**

I. INTRODUCTION

According to the data compiled from Center of Disease Control Morbidity and Mortality Weekly Report, there were 155 outbreaks and 431,846 cases of illness in public and individual U.S. water systems from 1991 to 2000 (Chlorine Chemistry Division of the American Chemistry Council, 2003) [1-6]. Worldwide, waterborne diseases remain the leading cause of death in many developing nations. According to the 2004 World Health Organization (WHO) report, at least one-sixth of the world population (1.1 billion people) lack access to safe water . The consequences are daunting: diarrhea kills about 2.2 million people every year, mostly children under the age of 5. The importance of water disinfection and microbial control cannot be overstated.

Chemical disinfectants commonly used by the water industry such as free chlorine, chloramines and ozone can react with various constituents in natural water to form disinfection by-products , many of which are carcinogens. More than 600 disinfection by-products DBPs have been reported in the literature (Krasner et al., 2006) [7]. The rapid growth in nanotechnology has spurred significant interest in the environmental applications of nanomaterials. In particular, its potential to revolutionize century-old conventional water treatment processes has been enunciated recently (USEPA, 2007; Shannon et al., 2008) [8-9]. Nanomaterials are excellent adsorbents, catalysts, and sensors due to their large specific surface area and high reactivity. More recently, several natural and engineered nanomaterials have also been shown to have strong antimicrobial properties, including chitosan (Qi et al., 2004) [10], silver nanoparticles (nAg) (Morones et al., 2005), photocatalytic TiO_2 (Cho et al., 2005) [11]; Wei et al., 1994) [12], fullerol (Badireddy et al., 2007) [13], aqueous fullerene nanoparticles (nC_{60}) (Lyon et al., 2006) [14], and carbon nanotubes (CNT) (Kang et al., 2007) [15].

II. EXPERIMENTAL SETUP

A. Materials

THF solvent was used with, rubber, copolymer, silane coupling agent and titanium precursor.

B. Procedure for Synthesis

The method employed to acquire desired results was to prepare stock solutions of polymer and solvent.

Different percentage of titania solutions were prepared. The basic concept was to functionalize our frameworks with different agents.

III. RESULTS

A. Coliform Count

After synthesizing the samples, equal amount of samples in the source water (200 ml) with 2 ml of contamination for 3 hours to know their disinfection power to purify contaminated source water. The results obtained as shown in *(Fig.2, Table.1)* that there was a continuous decreasing trend of coliforms in the samples which was desired.

Table 1. Total coliform, fecal coliform and E. coli count of various polymr/TiO_2 hybrids

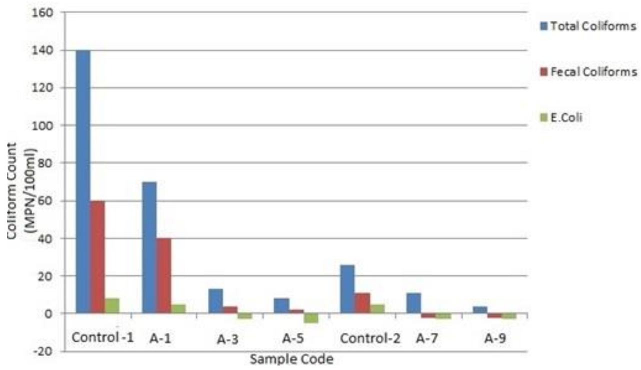

Figure .2. Total coliform, fecal coliform and E. coli profile of water samples treated using various polymer/TiO_2 hybrids

B. Thermal Stability

Thermal stability of the polymer/TiO_2 hybrid samples were verified by thermal gravimetric analysis (TGA) as weight loss versus temperature profiles of samples and thermal stability up to 450^{o}C have been achieved. There was continuous increasing trend of left yield at 600^{o}C which is a good sign for higher thermal stability achievements.

C. FTIR

Fourier transformed infrared spectroscopy was used to verify functional groups essential for required decomposing and disinfecting properties of polymer/titania hybrid frameworks.

D. FESEM

Field Emission Scanning Electron Microscopy was used to identify the structures of the polymer/TiO_2 hybrid frameworks and the structure was found to be porous which is useful for water disinfection by photo-catalysis.

IV. CONCLUSIONS

Successful fabrication of polymer/TiO_2 hybrid frameworks using a facile strategy was achieved. Enhancement of thermal stability and morphology of polymer/TiO_2 hybrid frameworks was achieved. Photo stability and non-leaching of TiO_2 particles in water was ascertained. Merely sunlight was used for complete water disinfection from fecal coliform and E. Coli.

V. SUMMARY

TiO_2 can decompose organic impurities, thus, making it the most promising nanomaterial in water treatment. Therefore, highly thermally stable hybrid polymeric frameworks were fabricated containing various TiO_2 content via a facile strategy. Finally, TiO_2 hybrids completely removed the E. Coli and fecal Coliforms without any disinfection byproduct using just the sunlight.

VI. REFERENCES

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