

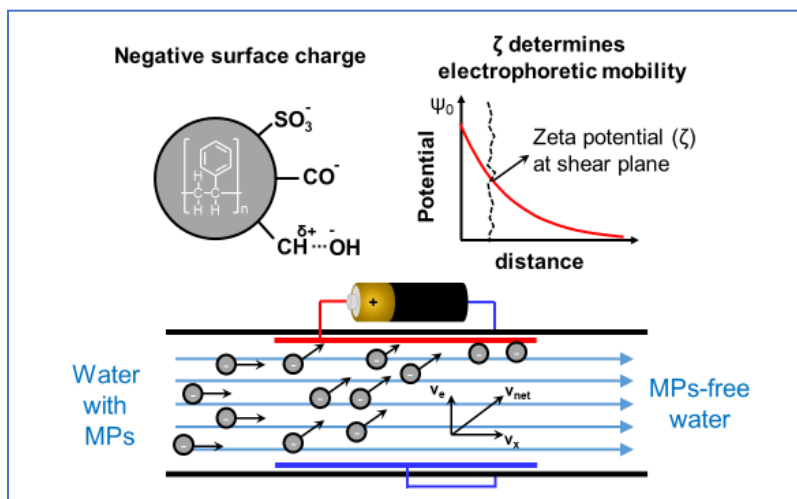
A Preliminary Analysis on the Separation of Ultrafine Plastics Particles from Water

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Graphical Abstract



Abstract

The presence of plastics particles, especially in the size range between nano and micrometer, i.e., the ultrafine class, is expected to be severe ecological and human health risks. The separation of ultrafine plastics from aquatic environment is crucial to the characterization and control of plastic materials in water. While plastics appear to be intrinsically inert, nonetheless, three mechanisms can be visualized to contribute charge to plastics surface. First, defects, both edge and bulk, created during synthesis, are the most accessible sites for initiating surface charges through ion



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adsorption. These edge and bulk defects also provide opportunity for reaction with water molecule, i.e., hydration reaction. Finally, dipole-dipole interaction between water molecules and surface electro-rich atoms such as N, Cl, O and S readily create hydroxo groups. Together, these reactions generate Bronsted acidity on plastics surface.

Electrophoresis is applied to analyze the surface charge (or zeta potential) of selected plastics particles, such as polystyrene (PS) and *polymethyl methacrylate* (PMMA) latex in simple electrolyte (NaClO_4) as a function of pH, particle size and particle number concentration. Results clearly indicated that the electrophoretic mobility (or zeta potential) was affected by particle size and particle number concentration, in addition to ionic strength and pH. For example, the electrophoretic mobility increased from -2.25 to $-1.0 \mu\text{m}\cdot\text{cm}/\text{V}\cdot\text{s}$ when the ionic strength was increased from 0.05 to 0.3 M in NaClO_4 electrolyte at PMMA concentration of 50 mg/L and pH 8.5 . The electrophoretic mobility decreased from -2 to $-4.5 (\mu\text{m}\cdot\text{cm}/\text{V}\cdot\text{s})$ when the preliminary particle size was increased from 30 nm to $2000 \mu\text{m}$. The variation of surface charge as affected by particle size and number concentration particularly was interpreted on the principle of electrical double layer.

Several forces govern the movement (and transport) of ultrafine particles including plastics in aquatic environment, gravity, friction and electrostatic. The terminal velocity of micro-plastics particles (particle size between 1 to $10 \mu\text{m}$) is controlled by electrostatic and gravity forces, whereas electrostatic force alone is the dominant factor controlling the transport of nano-plastic particles. Preliminary simulation on the separation efficiency of ultrafine plastics particles was conducted using continuous-flow reactor. Preliminary results showed that at applied DC voltage, E_{app} , equal or

greater than the critical separation potential, E_c , it is possible to achieve 95% separation of nano-plastics particles within 60 min from an electrostatic separator having a retention time of 20 min for plastic particles of the size of 5 μm and density of 1.2 g/cm^3 under E_c of 30 V/cm.

In conclusion, electrophoresis is feasible for the collection of ultrafine plastics particles from dilute surface water.

Keywords: electrophoresis, ultrafine plastics, surface charge, critical applied voltage, continuous-flow electrically assisted separator

Biography

Prof. Chin Pao (C. P.) Huang is the Donald C. Phillips Professor and the Francis Alison Professor at the University of Delaware in Newark, Delaware, USA. Prof. Huang received his BS degree in civil engineering from National Taiwan University, Taipei, Taiwan, in 1995. He then earned his MS degree in environmental engineering and Ph. D. degree in aquatic chemistry from Harvard University, Cambridge, Massachusetts, USA, in 1967 and 1971, respectively. Prof. Huang has advised the thesis research of over 50 Ph. D. and 70 MSs, and mentored a dozen of post doctors. Prof. Huang's research expertise is in thermodynamics and kinetics of chemical reactions at the solid-water interfaces. His recent research interests are advanced oxidation processes, environmental electrochemistry, and environmental nanotechnology. Prof. Huang has published over 300 refereed journal articles in addition to editor of six books. His current h-index is 86 with 27441 total citations according to Google Scholar. Among his many honors and award, Prof. Huang was a recipient of the Gordon Maskew Fair Medal of Water Environment Federation and Gordon Maskew Fair Award of American Academics of Environmental Engineers and Scientists. Prof. Huang was also the awardee of the Life-time Achievement Award of Asian-Americans Engineers of the Year.