Promoting a circular economy through sustainable wastewater and agricultural residue management

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Sustainable waste management practices will be essential in order promote a circular economy. The over exploitation of natural resources required to achieve economic growth and development has negatively impacted the environment. Consequently, the idea of a circular economy, which offers new ways to create a more sustainable economic growth model, is very attractive. Membrane based separations are attractive as they are environmentally friendly. Here the use of membranes for water treatment and conversion of agricultural residues to value added products is discussed.

In this presentation the use of electrocoagulation as a feed pretreatment operation prior to membrane distillation will be described. Today highly impaired hydraulic fracturing flow back water is typically reinjected into a geologically isolated formation in the Earth's crust. However, treating this highly impaired water for beneficial uses will promote a circular economy. The advantages of an integrated electrocoagulation, microfiltration and membrane distillation process for maximizing water recovery from hydraulic fracturing produced water will further highlight the potential for process intensification through integrated membrane based separation processes.

Taken together all aspects of the agricultural industry contribute more than 25% of world greenhouse gas emissions. Agricultural residues represent an abundant source of fuels and chemical intermediates. Conversion of these residues to valuable chemical intermediates will not only extend the carbon cycle but also promote a circular economy. Here lignocellulosic biomass hydrolysis and dehydration has been conducted using a synthetic polymeric solid acid catalyst consisting of dual polymer chains grafted from the surface of a ceramic membrane. The acidic polymeric chain, poly(styrene sulfonic acid) (PSSA) catalyzes biomass hydrolysis as well as dehydration. A neighboring poly(vinyl imidazolium chloride) (PIL) chain helps solubilize lignocellulosic biomass and enhance the catalytic activity. Hydrolysis was conducted for crystalline cellulose and acid, base or steam pretreated corn stover samples in ionic liquids (IL) and mixtures of IL with water or γ-valerolactone (GVL). Near quantitative total reducing sugar (TRS) yields for cellulose hydrolysis as well as pretreated corn stover biomass were achieved at mild conditions and in less than 12 h. Other lignocellulosic biomass residues have also been tested as feed streams.

Our novel, patented, polymeric solid acid catalysts are superior to cellulases as they can be operated at a higher temperature and at a much higher hydrolysis rate. These catalysts are stable and maintain high catalytic activity after repeated runs. Moreover, they can be easily regenerated and are environmentally friendly. These polymeric solid acid catalysts can be used not only for hydrolysis but also dehydration of cellulose leading to the production of 5-hydroxymethylfurfural (HMF) or levulinic acid.

Brief CV

Ranil Wickramasinghe is a distinguished professor in the Department of Chemical Engineering at the University of Arkansas where he holds the Ross E Martin Chair in Emerging Technologies. He is an Arkansas Research Alliance Scholar and Director. He is the Director of the Membrane Science, Engineering and Technology (MAST) Center, a National Science Foundation Industry-University Cooperative Research Center. Prof Wickramasinghe is the Executive Editor of Separation Science and Technology.

Prof Wickramasinghe obtained his Bachelor's and Master's degrees from the University of Melbourne in Chemical Engineering. He obtained his PhD from the University of Minnesota, also in Chemical Engineering. He worked for 5 years in the biotechnology/biomedical industry in the Boston area before joining the Department of Chemical Engineering at Colorado State University. He joined the Department of Chemical Engineering at the University of Arkansas in 2011. Prof Wickramasinghe has published over 200 peer reviewed journal articles, several book chapters and patents and is co-editor of a book on responsive membrane and materials. He is active in the American Institute of Chemical Engineers and was the Meeting Co-Chair for the 2017 International Congress on Membranes and Membrane Processes in San Francisco. He also serves on the Board of Directors of the North American Membrane Society.

Prof Wickramasinghe's research interests are in membrane science and technology. His research focuses on synthetic membrane-based separation processes for purification of pharmaceuticals and biopharmaceuticals, treatment and reuse of water and for the production of biofuels. Typical unit operations include: microfiltration, ultrafiltration, virus filtration, nanofiltration, membrane extraction, membrane distillation etc. A current research focus is surface modification of membranes in order to impart unique surface properties. His group is actively developing responsive membranes. These membranes change their physical properties in response to changed environmental conditions. A second research focus is the development of catalytic membranes for biomass hydrolysis by grafting catalytic groups to the membrane surface. He helped cofound SIEV Technologies, which is focused on commercializing the catalytic membrane technology developed by Prof Wickramasinghe's group.