Day 1 – Parallel Session 2

Track 2 – Bioenergy & Sustainable Feedstocks + Hydrogen Energy & Alternative Clean Fuels

KEYNOTE SPEAKER

Rice Husk Ash Upcycling into Mesostructured Silica Materials for Antiseptic and Electrochemical Application

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Abstract:

When disposed of using conventional methods such as landfilling, industrial and agricultural wastes contribute significantly to environmental degradation. With mounting concerns over resource depletion and sustainability, it is increasingly important to regard waste as a source of valuable materials. Among these, rice husk—removed during rice milling—stands out for its global prevalence, representing roughly 22% of the world's 760 million tons of rice production each year. In the Philippines alone, over 2 million tons of rice husk are generated annually, often used for energy production by calcination. After combustion, approximately 25% of rice husk is converted into rice husk ash (RHA), whose accumulation can cause air pollution through particulate emissions as well as contamination of water and soil if improperly managed. Remarkably, RHA contains a notably high silica content (80–97% SiO_2), exceeding that of other plant-based sources, with the remainder mainly composed of metal oxides. As a result, RHA is an especially promising feedstock for silica-based materials, offering the advantages of lower production costs and reduced carbon footprint compared to traditional sources like sand or quartz. Utilizing RHA as a precursor for mesostructured silica materials is therefore appealing, as these materials offer large surface areas and tunable pore structures ideal for applications in drug delivery, catalysis, and environmental remediation. In this presentation, we highlight our recent progresses in using RHA as silica precursors for the sol-gel synthesis of antiseptic MS powder materials and for the electro-assisted self-assembly (EASA) of mesoporous silica films on electrodes for permselective analysis. The research is the outcome of an international collaboration consortium led by the Institut Charles Gerhardt Montpellier (ICGM, University of Montpellier) with the Research Center for Advanced Ceramics in the Philippines (Mindanao State University), the Centre for Functional and Surface Functionalized Glass in Slovakia, and the Polish Academy of Sciences. RHA (sourced from a power plant company in the Philippines) was chemically converted into a stable silicate solution that was used as silica precursor in sol-gel synthesis. We inferred that cetylpyridinium chloride (CPC), a simple molecule, is capable of simultaneously serving as a structure-directing agent in sol-gel synthesis and as an antimicrobial component (see Figure 1). CPC is a well-characterized, FDA-approved surfactant distinguished by its broad-spectrum antimicrobial properties and established safety in topical and oral formulations. This study presents the first synthesis of hybrid mesoporous silica materials derived from rice husk ash employing CPC micelles, alongside their structural optimization. Integrating functional antimicrobial agents directly during synthesis obviates the use of hazardous chemicals and minimizes the energy demand typically associated with post-modification steps. The antimicrobial performance of these materials was systematically assessed against several microorganisms, including aerobic bacteria (Staphylococcus aureus, Enterococcus faecalis), anaerobic bacteria (Streptococcus mutans, Porphyromonas gingivalis), and yeast (Candida albicans).