Mechanical Engineering Doctoral Defense

Direct Ink Written Luminous Monoliths for Hydrogen Sulfide Photocatalysis

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Abstract

The conversion of H2S enables the recycling of a waste gas into a potential source of hydrogen at a lower thermodynamic energy cost as compared to water splitting. However, studies on the photocatalytic decomposition of H2S focus on traditional deployment of catalyst materials to facilitate this conversion, and operation only when a light source is available. In this study, the efficacy of Direct Ink Written (DIW) luminous structures for H2S conversion has been investigated, with the primary objective of sustaining H2S conversion when a light source has been terminated. Additionally, as a secondary objective, improving light distribution within monoliths for photocatalytic applications is desired. The intrinsic illumination of the 3D printed monoliths developed in this work could serve as an alternative to monolith systems that employ light transmitting fiber optic cables that have been previously proposed to improve light distribution in photocatalytic systems. The results that were obtained demonstrate that H2S favorable adsorbents, a wavelength compatible long afterglow phosphor, and a photocatalyst can form viscoelastic inks that are printable into DIW luminous monolithic contactors. Additionally, rheological, optical and porosity analyses conducted, provide design guidelines for future studies seeking to develop DIW luminous monoliths from compatible catalyst-phosphor pairs. The monoliths that were developed demonstrate not only improved conversion when exposed to light, but more significantly, extended H2S conversion from the afterglow of the monoliths when an external light source was removed. Lastly, considering growing interests in attaining a global circular economy, the techno-economic feasibility of a H2S-CO2 co-utilization plant leveraging hydrogen from H2S photocatalysis as a feed source for a downstream CO2 methanation plant has been assessed. The work provides preliminary information to guide future chemical kinetic design characteristics that are important to strive for if using H2S as a source of hydrogen in a CO2 methanation facility.

July 7, 2023, 10:00 AM; ECG G320