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CONTINUOUS UPGRADING OF GLUCOSE TO COMMODITY CHEMICALS USING LEWIS ACIDIC ZEOLITE CATALYSTS

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ETH Hönggerberg, HCI H 2.1

Abstract: Transition to net zero requires non-renewable resources to be replaced with renewable alternatives. In the chemical industry, one target is to substitute petroleum for annually renewable, non-edible organic matter ("biomass"). In fact, along with being renewable, biomasses such as agricultural and food waste, or energy crops that can grow on marginal land, are highly functional, chemically diverse, and yield products with low carbon footprints, giving them excellent potential as raw materials for chemical manufacture. Turning biomass into chemicals requires researchers to develop ways to rearrange the chemical bonds of biomass into the structures needed in society. A promising approach involves the use of heterogeneous catalysts, which are solid materials that speed up chemical reactions without being used up during the process. This is how the chemical industry converts petroleum to chemicals. However, as the chemical composition and structure of biomass differs greatly to that of petroleum, it cannot be used as a simple drop-in substitute feedstock. As such, catalysts and catalytic processes that have undergone 100 years of development in the petrochemical industry are not necessarily suitable for this new type of chemistry. Thus, we need new catalysts and new catalytic processes to transition to a net zero society. During this presentation, I will highlight some of my team's research focused on the upgrading of glucose over Lewis acidic zeolite catalysts. Case studies related to the retro-aldol fragmentation of glucose to alpha-hydroxyesters (e.g. methyl lactate), and the isomerization of glucose to fructose, will be covered. Research on catalyst discovery and the synthesis of inorganic materials [1], reaction optimization and scale up [2], alongside mechanistic studies and operando spectroscopy [3, 4], will be presented. I will show how this combination of activities has allowed us to overcome several of the bottlenecks holding back the production of renewable chemicals, including minimising rapid deactivation of heterogeneous catalysts [5], and maximising the carbon efficiencies of the desired chemical processes [6]. References: [1] Navar et al., J. Mat. Chem. A. 10 (2022) 22025; [2] Botti et al., ACS Sust. Chem. Eng. 10 (2022) 4391; [3] Botti et al., ACS Catal. 11 (2021) 1296; [4] Tarantino et al., Cat. Today 429 (2024) 114459; [5] Botti et al., ACS Catal. 10 (2020) 11545; [6] Botti et al., Angew. Chem. Int. Ed. 59 (2020) 20017.

Bio: Ceri Hammond is a Royal Society University Research Fellow, based at the Department of Chemical Engineering at Imperial College London. He studied for his undergraduate degree at the School of Chemistry at Cardiff University, and performed his doctoral research at the Cardiff Catalysis Institute under Prof. Graham J. Hutchings FRS. He then spent periods at D-CHAB at ETH Zürich (Prof. Ive Hermans), and later the Department of Chemistry at Stanford University (Prof. Edward I. Solomon), prior to establishing his independent lab at the Cardiff Catalysis Institute following the award of my URF. Since January 2020, he has worked at Imperial College London, where he is currently a Reader (Assoc. Prof) in Catalysis.