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CATALYTIC STEAM REFORMING OF SYNGAS HYDROCARBONS TO MAXIMISE HYDROGEN PRODUCTION - A THERMODYNAMIC STUDY

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Abstract

Hydrogen is an energy source of the future. It is imperative to develop competitive hydrogen production technology from renewable sources such as biomass. The biomass can be converted to hydrogen through gasification to produce syngas, a mixture of hydrogen, tar, methane, carbon monoxide, carbon dioxide and other hydrocarbon gases. Tar has been a challenge as it easily condenses at lower temperatures and may severely block equipment. However, tar and other hydrocarbons present in syngas could be catalytically reformed to produce hydrogen and thus maximise hydrogen production, which can be subsequently separated from other syngas species. Current reforming catalysts suffer from deactivation caused by sulphur present in syngas; this worsens the gasification process performance and often causes unwanted side reactions. Sulphur deactivation could occur through mechanisms of sulphidation, alteration and coke formation. To develop a solution for preventing sulphur deactivation, a novel catalyst composition $Ni_xCo_{(1-x)}CeO_3$ is proposed and formulated. A thermodynamic simulation of syngas reforming was conducted to gain a foundation reference indicating the novelty of the catalyst performance, and the novel catalyst considers sulphur resistance being rendered by labile lattice oxygen which oxidises chemisorbed sulphur to gaseous sulphur oxides. Further kinetic modelling has been performed using kinetic data for existing catalysts, it was found to be operating at 44% of thermodynamic hydrogen production rate, meaning there is a significant performance gap the catalyst in this research needs to cover. Thermodynamic simulation predicted ideal reforming temperature of 650-700°C for maximum conversion. Important parameters (e.g., steam to carbon ratio, gas hourly space velocity) and insights have been obtained for use in next phase of the research work on assessing catalyst performance. Figure 1 below illustrates the proposed mechanism for the novel catalyst resistance to sulphur and coke, and Figure 2 shows the results of the thermodynamic and catalytic simulation for syngas reforming.

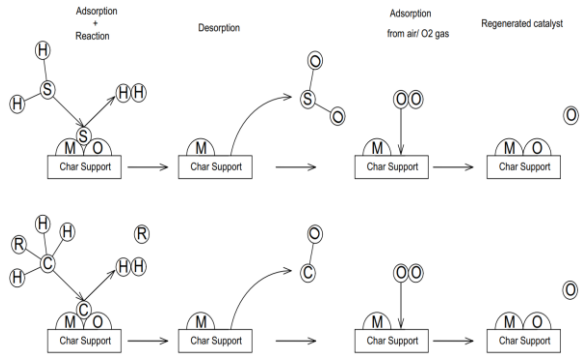

Figure 1: Proposed mechanism for the novel catalyst resistance to sulphur and coke. M represents Ni/Co

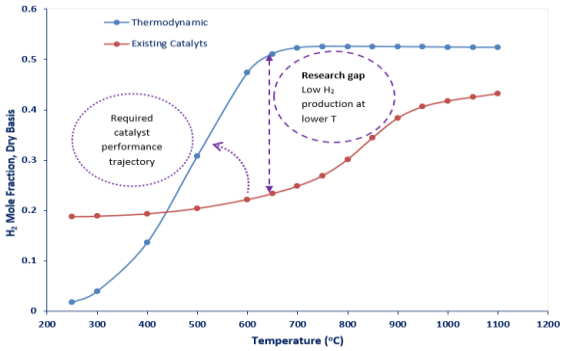

Figure 2: Thermodynamic and catalytic simulation of syngas reforming