Water Gas Shift Catalysts for Clean Hydrogen from Coal

R. Radhakrishnan[1*], Z. Dardas, S. C. Emerson, S. Opalka, S. Tulyani, T. Vanderspurt, R. R. Willigan
[1]*United Technologies Research Center, East Hartford CT 06118 (USA)*
* rradhakr@utrc.utc.com, 860-610-7957

Introduction

Water gas shift (WGS) reactors are critical components for industrial coal to hydrogen plants and for fuel processors used in fuel cell applications. United Technologies Research Center (UTRC) started development of advanced WGS catalysts in 2000 to address needs for the UTC Power fuel processing systems. The development effort concentrated on ceria-zirconia based noble metal systems[1]. Platinum-rhenium catalysts (ratio 2:1) supported on ceria-zirconia oxides were found to be ideal for low temperature <300 °C shift reactions. At the higher temperatures needed for membrane reactors, ~400 °C, Pt-Re supported on more complex ceria based oxide systems $Ce_{[1-(x+y)]}M'_xM''_yO_2$ were needed [2]. These were found to provide some sulfur tolerance. This work has been extended under DOE Contract DE-FC26-05NT42453 to nano-engineered catalysts designed to operate under higher pressures (nearly 42 atm) and higher sulfur concentrations (partial pressure $4*10^{-3}$ atm). These conditions represent coal gas reformate envisioned for future generation coal to hydrogen plants that are part of the DOE – Office of Fossil Energy Hydrogen from Coal initiative. This poster will discuss the performance of a new family of catalysts designed with the aid of quantum mechanical modeling to meet the requirements of this initiative.

Materials and Methods

This poster will concentrate on the experimental methods used screen the catalysts in a 5 tube test rig and various pressures and gas compositions.

Results and Discussion

Experimental results and kinetic expressions summarizing the performance of various members of the new family of catalysts, Pt-Re/$Ce_{[1-(x+y)]}M'_xM''_yO_2$ will be presented along with data showing how the performance varies at increased pressure as a function of the elements M' and M" as well as the coefficients x and y in the presence and absence of sulfur.

Significance

The goal of this program is a robust sulfur tolerant catalyst suitable for economically viable operation in an Advanced Water Gas Shift Membrane Reactor for the conversion of precleaned coal gas to high purity hydrogen.

References

1. Vanderspurt, T.H. ; Wijzen, F. ; Tang, X. ; Leffler, M. P. ; Willigan, R. R. ; Newman, C. A.; Radhakrishnan, R.; Feng, F. ; Laube, B. L. ; Dardas, Z. ; Opalka, S.M. ; She, Ying , U.S. Pat. Appl. 20030235526, 2003.

2. Vanderspurt, T.H.; Willigan, R.R. US Pat. Appl. 2006023369 , 2006.