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Master Thesis:	**Green Methanol Synthesis from CO_2/H_2 on Au/ZnO Catalysts: Active Intermediates**
Work description:	Methanol synthesis from CO_2 and H_2 generated from renewable energies via eq. 1 is an attractive option for storing excess electric energy, e.g. from wind power and photovoltaics, and at the same time reduce CO_2 emissions. $CO_2 + 3\ H_2 \rightarrow\ CH_3OH + H_2O$ (eq.1) We recently found that Au/ZnO catalysts are at least comparably active as the benchmark Cu/ZnO catalysts. In addition they show lower tendency for the undesired formation of CO via the reverse water gas shift reaction (eq. 2) $CO_2 + H_2 \rightarrow\ CO + H_2O$ (eq. 2) and they are more stable with respect to dynamic operation. To learn more about the reaction mechanism, adsorbed reaction intermediates and their buildup / decay during reaction shall be investigated by *in situ* IR measurements performed during the reaction at elevated pressure. Isotope exchange experiments, changing from $^{12}CO_2/H_2$ to $^{13}CO_2/H_2$ and $^{12}CO_2/H_2$ to $^{12}CO_2$ / D_2 gas mixtures at 240°C and pressures of 2, 5 and 10 bar, are planned to separate reaction intermediates from reaction side products. Additional information on the rate limiting step is obtained from changes in the methanol formation rates during isotope exchange (kinetic isotope effects (KIE)). Additional measurements on Au catalysts with low methanol formation activities (Au/Al_2O_3, Au/TiO_2) are planned to obtain further information on the physical origin of the high activity of Au/ZnO. This will include the comparison of the CO adsorption characteristics, in particular the formation of $Au^{\delta-}$ species, and of other adspecies on these catalysts with Au/ZnO under identical reaction conditions. In this work the student will learn to handle modern techniques in Heteogeneous Catalysis research, and acquire in depth knowledge of modern concepts in Catalysis.
Financial Support:	Up to 35 hours per month in Hiwi jobs possible (ca. 400,- € / month)
Target group:	Students of Chemistry, Chemistry & Management or CE
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