and temperature on the ester product yield were determined. The acetate-resin catalysts were characterized using different analytical techniques including FTIR-ATR, GC-MSD, liquid N2 adsorption isothermal method at 77 K. The FTIR structural identification of components showed various functional groups including C-H, C=O and O-H bonds on the spectra. The surface area and the pore size distribution analysis was determined using the BET and BJH methods respectively. The BET results of amberlyst 36 resin catalyst was found to be high (8.908 m^2/g) in contract to dowex 50W8x (0.497 m^2/g) while the BJH pore size distribution of the resin catalysts exhibited a type IV/V isotherm with hysteresis confirming a mesoporous structure. The esterification product was investigated and ethyl lactate was identified at ion 45 on the mass spectra. The produced ester exhibited a higher percentage yield of up to 100 %.

14.2 Advanced Catalytic Hybrid Inorganic Membrane Integration for CO_2 Conversion from Flue Gas (Edward Gobina, Edidiong Okon, Habib Shehu and Ifeyinwa Orakwe)

In this work, a catalytic membrane reactor for the tri-reforming of power plant flue gas for CO_2 conversion was carried out at two different temperatures of 800 and 900 °C using 10 mm and 25 mm OD membranes respectively for the reaction. Rhodium chloride ($RhCl_3$) solution was used as a precursor catalyst for impregnation on the surface of the α-Al_2O_3 inorganic membrane. For each membrane the 0.5 wt.% Rh/gamma-Al_2O_3 catalyst gave the higher conversions of CH_4 and CO_2 but the syngas ratio did not change significantly with increasing catalyst loading from 0.1 weight % to 0.5 weight %. It was observed that at 900°C, the CO_2 conversions remained high and desired H_2:CO ratios could also be attained without excessive deactivation of the catalyst. However, lower CO_2 conversions were observed at 800 °C. CO_2 reforming is more favorable at high temperatures, it was determined that by raising the temperature to the 900 °C range CO_2 conversion could be increased. It was also observed that for identical flowrates, and catalyst loading the conversion in the 25 mm OD membrane is always higher than that for the 10 mm OD reactor. Overall, the results have confirmed that variation in temperature and feed gas stream has a direct effect on the CO_2 and CH_4 conversion levels and H_2/CO output concentrations. Higher temperatures (900 °C) was observed to be more favorable for CO_2 conversion. The scanning electron microscopy coupled with energy dispersive analysis of x-ray (SEM/EDAX) was also used for the characterization of the sample. Rh dispersed on the surface of the support was clearly visible as a bright spot on the SEM images.

14.3 MEA with Non-Precious Catalysts and Anion Conductive Membrane for Electrochemical Water Splitting (Galin Borisov, Katerina Maksimova-Dimitrova, Hristo Penchev, Filip Ublekov, Elefteria Lefterova, Vesselin Sinigersky and Evelina Slavcheva)

The work presents a research on the preparation and properties of non-precious monometallic catalysts (Ni and Co) synthesized by sol gel method and homogeneously dispersed on titanium sub-oxide carrier. The catalysts are characterized concerning morphology and surface structure, then integrated in membrane electrode assemblies (MEA) with anion exchange membrane comprising para-polybenzimidazole doped with potassium hydroxide. The MEA electrochemical performance and catalytic activity toward the hydrogen and oxygen evolution reactions (HER and OER) are investigated in a homemade electrolysis test cell. The results obtained show low overpotentials for both OER and HER compared to a MEA with Pt catalyst, as well as stable performance in the temperature range up to 80 °C. The current density reaches 0.2 $A.cm^{-2}$ at cell voltage of 2.0 V.

14.4 Hydrogen Separation in a Plasma Membrane Reactor (Shintaro Wakazono, Yukio Hayakawa, Kota Shizuya, Kenya Tokunaga, Shinji Kambara and Tomonori Miura)

A typical Pd-Cu hydrogen separation membrane is operated at a temperature of 450°C and at a differential pressure of 1.0 MPa. Therefore, the short lifetime of the membrane is an inevitable issue. To solve the issue, a plasma membrane reactor, which is a plasma reactor integrating a hydrogen separation membrane, has been developed. The effects of the applied voltage, gas flow rates, and differential pressure on the flow rate of the separated hydrogen were investigated to determine the best operating conditions for the plasma membrane reactor. 100% H_2 gas was used as a baseline gas, and 75% H_2 with 25% N_2 was used as the impure gas. The plasma membrane reactor was able to separate hydrogen at a temperature of below 200°C and at a