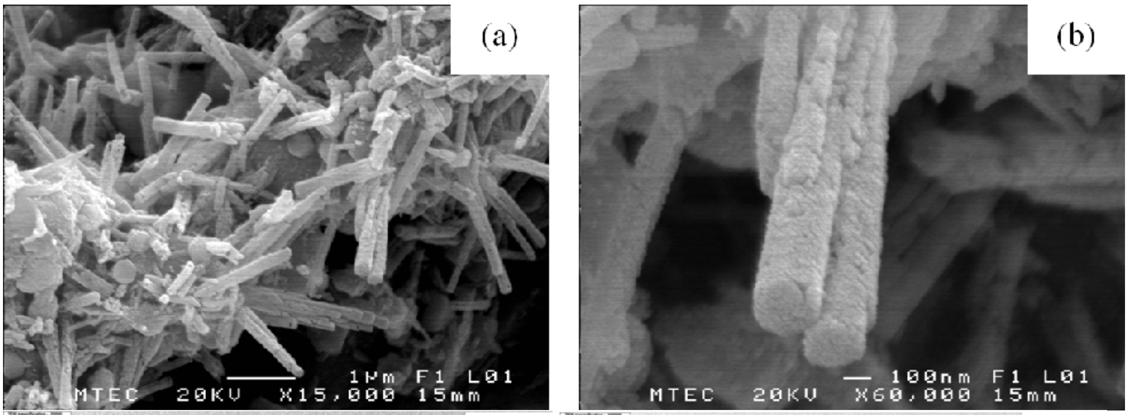
One-dimensional ZnO nanorods were grown on ZnO nanoparticles seeded porous ceramic substrates by using equimolar concentration of zinc nitrate and hexamethylenetetramine at temperatures lower than 100 °C. The dimension of nanorods could be controlled through various growth conditions such as reactant concentration, pH of growth solutions and growth time. ZnO nanorods on ceramic substrates were utilized as a catalyst itself and a catalyst support for methanol steam reformation. Catalytic activity of ZnO nanorods for methanol steam reforming process was found to depend on the terminated surfaces of ZnO crystallites. Copper (Cu), palladium (Pd) and gold (Au) nanoparticles infused ZnO nanorods were prepared by in-situ precipitation of the metals on the nanorods. The highest hydrogen selectivity was observed with Cu/ZnO nanorods, while Pd/ZnO nanorods showed slightly lower activity. Higher catalytic activity of copper and palladium impregnated ZnO nanorods can be attributed to the synergistic combination of bimetallic oxides. In contrast, Au/ZnO nanorods showed very high activity for methanol dehydrogenation and higher than 97% methanol conversion was achieved for operating temperatures as low as 200 °C. Surface treatment of ZnO nanorods under UV irradiation during precipitation process was found to further improve catalytic activity on methanol reforming process. Hydrogen selectivity could be significantly enhanced using UV assisted Cu/ZnO catalysts while an increase of carbon monoxide selectivity was attributed to the water gas shift reaction.

In addition, Cu/ZnO microballs were synthesized by a two-step process, first with the growth of ZnO nanorods followed by the conventional impregnation of copper nanoparticles. Catalytic activities for methanol steam reforming by using Cu/ZnO microballs were found to increase with increasing copper content. Activation energies of catalysts prepared during this work and CuZnAl commercial catalyst were calculated from the Arrhenius plots of the rate of reaction and were found to be strongly related to the hydrogen yield. The lowest activation energy was found for Cu/ZnO microball catalysts, lower than the activation energy of CuZnAl commercial catalysts. Co-precipitation was the other technique utilized to prepare Cu/ZnO microballs but was found to have lower activity on methanol steam reforming due to the lower copper content in the catalysts.

Furthermore, Zinc stannate was successfully synthesized by a two-step hydrothermal growth technique, where ZnO nanorods were grown in the initial step followed by co-precipitation of tin ions available from the additional stannate tetrachloride solution and zinc ions from the dissolution of ZnO nanorods under hydrothermal process. Zinc stannate was found to be active for methanol reformation and > 90% methanol could be reformed at 350 °C.

Solar energy harvesting was performed for heating the methanol steam reformation system using solar concentrators using reflectance or by using a parabolic mirror. The highest temperature of 190 °C could be achieved using parabolic mirror while 140 °C was obtained using a reflection chamber. Continuous reformation processes were conducted for 6-8 hours using the solar concentrator system and found to produce stable hydrogen yield throughout the reformation period.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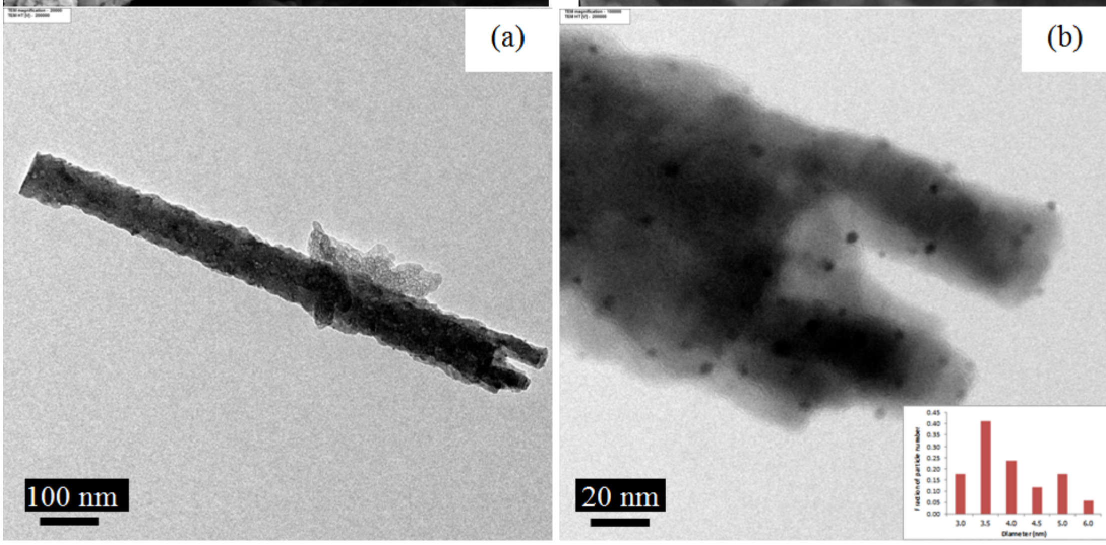
(a)
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