

## Preface

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The factors contributing the climate change, pollution or greenhouse gasses must be check for the betterment of upcoming generations. Sustainability of future energy sources is still a matter of debate. Recently, there is a successful commercialization of fuel cell technology and other appliances to practice the hydrogen as an energy carrier. The future fuel cell technology in market required more renewable hydrogen generation in the near future. The huge amount of hydrogen production is vital to fulfilling our requisite but not at the cost of environmental disputes. Hence, it requires the renewable sources of hydrogen. On industrial scale, thermal steam reforming is upcoming sustainable approach comparative to other available options. Considering these scenario ethanol steam reforming (ESR) is one of the best option for hydrogen generation in the near future. The cost of catalyst contributes the overall cost of hydrogen. Recent studies confirms that the noble metal catalysts are more active compared to non-noble, but noble metal catalysts are not cost effective. However, noble metal catalysts are typically highly stable, but deactivation by carbon deposition were reported too. Hence, the deactivated catalyst regeneration or catalyst reformulation from deactivated catalyst could be a cost effective approach. If the high temperature tolerant catalyst can be synthesized then after carbon deposition it can be regenerated by oxidation of carbon at optimum temperature.

Among non-noble metal catalyst Ni and Co has viable catalytic performance regarding hydrogen selectivity. In metallic state, Co is not only active to perform the ESR but also facilitates the filamentous carbon formation and get deactivated. Study of temperature program reduction showed that reduction of NiO is easy if the interaction between the support and metal is weak. But it is not only facile to be sintered but also resulted in formation in larger particles, vulnerable for carbon formation. However, this

deactivated form of metal and carbon mixture contains highly dispersed metal. The strong interaction between metal and support leads to lower generation of carbon. A number of workers studied ESR on the noble and non-noble metal over different kinds of oxide support such as  $\text{Al}_2\text{O}_3$ ,  $\text{CeO}_2$ ,  $\text{ZnO}$ ,  $\text{MgO}$ ,  $\text{ZrO}_2$  and  $\text{SiO}_2$  with variation of metal loading.

Therefore, considering these scenario this work includes the active non noble metal catalyst, the deactivation of catalyst, reformulation of deactivated catalyst, effect of pre-treatment conditions on catalyst for ESR and bimetallic non noble nano catalyst for ESR. The physico-chemical properties of catalysts were characterised with several instrumental techniques such as HR-XRD, ATR-FTIR, HR-SEM, TEM with SAED, EDAX, surface area analyser and TPR. The carbon deposition mechanism involved in Co catalyst was explored. The perovskite-cobalt composite catalyst was prepared via nanocasting approach from the spent catalyst deactivated by carbon deposition. The reduction atmosphere as well as redox atmosphere effects on product selectivity by nano Co/ $\text{CeO}_2$  based catalyst was analysed. The special structured mixed metal oxide such as spinel, perovskite and hydrotalcite have a homogenous distribution of atoms as well as excellent sintering stability. Therefore, ZSM-5 supported Ni and Co based catalyst was used for ESR performance. The bimetallic effect of Ni and Co was also evaluated and  $\text{CeO}_2$  supported nano bimetallic catalyst was optimized for ESR reaction. The novel route of nano catalyst was also discovered and the activity of synthesized catalysts were evaluated by performing ESR. Investigations were carried out on influence of reaction variables such as loading of active bimetallic catalyst, water: ethanol molar ratio, reaction temperature, and catalyst reusability to find out optimal reaction conditions.

