CHAPTER 2

AIM AND SCOPE OF THE INVESTIGATION

2. Aim and Scope of the investigation

In this chapter, the detailed work plan, and ultimate aim and scope of the work to be carried out during the course of this doctoral work is narrated. Care has been taken to cover all aspects of the experimental approaches to the problem of unfolding the effect of preparation techniques on the characteristics and performance of final catalysts.

2.1. Objective:

The major objective of the thesis is to elucidate the application of sol-gel route for preparation of alumina support and Sn promoted Pt/Al_2O_3 catalysts. The catalyst systems and the support chosen for study are those useful for the dehydrogenation of normal (C_{10} to C_{14}) paraffins, a key step towards producing LAB (Linear Alky Benzene), a raw material for making synthetic detergents. Both reaction as well as the catalyst systems, reveal certain interesting features.

Dehydrogenation of paraffins is an equilibrium controlled endothermic reaction that is accompanied by several side reactions like secondary dehydrogenation, aromatization, cracking and coking. It also requires extremely severe reaction conditions, higher temperature (> 450°C), lower operating pressure (conducive for coke formation and consequent loss of catalyst activity), high space velocity and controlled dosing of moisture (that may induce slow sintering of Pt crystallites) to contain excessive coking and typically lower paraffin conversion in the range 12-14% so as to obtain maximum mono olefins selectivity.

Design of a suitable catalyst for such a reaction remains a challenge till date. Not with standing the lower per pass conversions, improvements in mono olefins selectivity and achieving longer cycle life (from the 40 to 50 days at present) are the targeted areas for research activity. Modified $Pt\text{-}Sn/Al_2O_3$ catalysts continue to be the most efficient systems for this application, for which the basic design features are:

- Maximum platinum metal dispersion for achieving desired activity/conversion
- Attenuation of acidity to minimize acid catalyzed side reactions
- Selection and optimization of promoter levels and promoter-platinum interactions towards maximizing selectivity
- Modulation of porosity of alumina support to retard deactivation by coking

All such unique features of the catalyst like, textural properties, metal dispersion, metal-metal and metal-support interactions, acidity, active sites of specific composition, structure and geometry are acquired during its preparation. It is for this reason that preparation methods have gained immense importance and several modifications in conventional routes for preparation of supported metal catalysts in general, and Pt/Al_2O_3 catalysts in particular, are being attempted. Of these, sol-gel method for preparation of catalysts holds good potential since the it could be adopted to tailor-make catalysts for specific applications. Besides, the intricate molecular level mixing of the active components (Pt and Sn) during preparation of catalysts via sol-gel route could induce specific interactions leading to novel catalysts. There are only two reports **(1, 2)** on the preparation of $Pt\text{-}Sn/Al_2O_3$ catalysts by sol-gel routes and their application for dehydrogenation of isobutane and propane. To the best of our knowledge, there has not been any report on the application of sol gel catalysts for dehydrogenation of long chain paraffins. Even in the case of the two available reports, subtle variations in preparation methods have lead to conflicting reports on the suitability of sol-gel made catalysts for this application. Hence a systematic study on preparation and characterization of a series of $Pt\text{-}Sn/Al_2O_3$ catalysts by sol-gel route and evaluation of their activity, selectivity and deactivation patterns for dehydrogenation of n-decane has been undertaken.

In this thesis it is proposed to study the influence of several preparation parameters in sol-gel method and arrive at optimum conditions. Role of mono and bifunctional catalysts and inter relationships between preparation method- properties-performance with respect to the paraffin dehydrogenation reaction have been explored. Broadly, the scope of the thesis includes:

- Studies on the effect of preparation parameters on the textural properties of alumina
- Characterization of alumina by thermal and spectroscopic techniques, electron microscopy, acidity, textural and structural properties vis-à-vis alumina support obtained by conventional route.
- Preparation of bifunctional and monofunctional mono metallic and bimetallic supported metal catalysts via sol-gel as well as conventional methods
- Characterization of the catalysts for metal dispersion, temperature programmed reduction, diffused reflectance spectroscopy, the nature of acid sites by butene-1 isomerisation and coke analysis on spent catalysts

- Studies on the dehydrogenation of n-decane as a model reaction on these catalysts and arrive at correlations between activity, selectivity and aspects of catalyst deactivation on one hand and the catalyst characteristics on the other.
- Studies on the effect of preparation parameters on the characteristics and catalyst performance in the model reaction.
- Studies on the effect preparation parameters on catalysts with various Sn/Pt ratio (0 to 8), especially regarding Pt-Sn-support interactions and their relevance to the model reaction.
- Establish the significance of sol-gel technique in the inter-relationships between preparation-characterization and performance of the catalysts.

It is hoped that such studies would pave way towards establishing correlations / concepts on preparation-characterization-performance of the catalyst and at the same time help in the design of superior catalyst formulations.

References:

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