1. INTRODUCTION

Environmentally safe functional catalyst for organic reactions is an emerging field of ‘green chemistry.’ The nanotechnology guided design and synthesis of novel catalysts show enhanced performance in their catalytic activity or selectivity. Chemical industries engaged in synthetic organics especially design and synthesis of drug intermediates, natural products, bioethanol and oil extraction seriously looking for new molecular/catalyst materials. Many nano catalysts show regenerative quality by thermal or chemical treatments for repeated use and it reduces the cost of the chemical synthesis. Economically, the nanostructured catalysts have societal benefits in their energy efficiency as well as by cutting the hazardous gaseous emissions and minimizing the industrial water pollution [1]. Metal nano catalysts exhibit large surface areas have been employed as catalysts very successfully even today for many industrial chemical processes [6–9]. Swelling nature and ion exchange property of the clays are the important advantages in clay catalysts where one can exchange bulky organic cations easily during synthesis.

Supported noble metal catalysts with particle size down to a few nanometers are recommended in today’s chemical processes. Importantly, deliberate tailoring of particle size, shape and surface could lead to improved or new catalytic properties. The generation of metal particles of nanometer size in the interlamellar space of the clay minerals was found to be a favorable technique for synthesizing well dispersed and stable metal catalysts. The use of such catalysts in selective hydrogenation reactions overcomes the disadvantages like poor metal reduction, less selectivity, side reactions like condensation and cyclisation met with the conventional porous and supported catalysts.

Heterogeneous catalysts used in hydrogenation reactions contain usually an active metal species supported on a carrier. The metal is able to adsorb hydrogen thus making hydrogenation reaction possible. The carrier is able to disperse the metal to smaller particles as compared to bulk metal enhancing the specific surface area have been employed as catalysts very successfully even today for many industrial chemical processes [6–9]. Swelling nature and ion exchange property of the clays are the important advantages in clay catalysts where one can exchange bulky organic cations easily during synthesis.

Keywords: platinum, ruthenium, montmorillonite, hectorite, selective hydrogenation, cinnamaldehyde, liquid phase

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Nanoparticles. An ideal nanoparticle catalytic system should not only be catalytically accessible but also morphologically stable or controllable.

The interlayer space available in the clay minerals was found to be a very good nano phase reactor to host finely dispersed metal catalysts without aggregation [20, 22, 23]. In this work noble metal intercalated/impregnated clays have been developed for a few selective organic synthesis reactions.

Hydrogenation of \( \text{C} = \text{O} \) bond alone is more difficult than \( \text{C} = \text{C} \) bond hydrogenation in \( \alpha, \beta \) unsaturated aldehydes due to that thermodynamic and kinetic data [32] favour the hydrogenation of only \( \text{C} = \text{C} \) bond. This decade long difficulty is to be solved in the area of fine chemical synthesis. In this context selective hydrogenation of cinnamaldehyde to cinnamyl alcohol has become one of the highly potential organic transformations in fragrance and flavour industries [33–37]. In general, acquiring maximum selectivity with high conversion is a tough task. This is because of various factors such as nature of the metal, nature of the support, method of synthesis, particle size of the metal catalysts, solvent, reaction temperature, hydrogen pressure etc. have individual influence in determining the activity and selectivity of the catalysts. The effect of all the above parameters on the conversion and selectivity in the selective hydrogenation of cinnamaldehyde has been reported in the review by Maki Arvela et al. [10] and references therein. It is known that a properly designed catalyst should strongly polarize only the carbonyl group of the adsorbed aldehyde molecule for the adsorption and enhance its reactivity towards hydrogen. Hydrogenation of cinnamaldehyde was studied over different transition and noble metals supported on various conventional supports like metal oxides, mesoporous materials and smectite type clays [16, 38]. Among the various noble metal catalysts studied, platinum and ruthenium were found to produce more promising results towards the selective hydrogenation of cinnamaldehyde in liquid phase due to their larger d orbitals compared to Pd [39].

Here we presents the results obtained in the liquid phase hydrogenation of cinnamaldehyde over synthesized platinum or ruthenium intercalated montmorillonite/hectorite catalysts at different temperatures and hydrogen pressures. The effect of solvent and time on stream on the conversion and selectivity were studied and discussed. Comparison of catalytic activity of the intercalated hectorite catalysts and the impregnated catalysts was also made with respect to hydrogenation of cinnamaldehyde.

2. EXPERIMENTAL METHODS

2.1. Synthesis of Metal Intercalated Clay Catalysts

Known amount of montmorillonite was first ion exchanged by stirring with 2 M NaCl solution to ensure that all the exchangeable cations are only Na⁺.