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Enhancement of Heterogeneous Reactions (Liquid-Solid) Using Microphase

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Abstract: Liquid solid non-catalytic reactions are one class of heterogeneous reactions. In the present study, alkaline hydrolysis of solid esters was under taken. Reactions like alkaline hydrolysis of solid esters usually limited by the diffusion of sparingly soluble solute into the liquid phase in which reaction occur. The reaction was carried out between solid ester (phenyl benzoate) and sodium hydroxide for various particle sizes in the laboratory. The conversion of various particle sizes of phenyl benzoate is calculated. The diffusion coefficient is calculated.
Keywords: Liquid-solid, non-catalytic, alkaline hydrolysis, solid ester, diffusion, rate.

Introduction:

An area of great importance is the enhancement of reaction rates to make practically feasible reactions which are otherwise not possible or need large reaction volumes and long reaction times for reasonable yields. Microphase, microemulsions ultrasound and phase transfer catalysis are some of the methods which can be used to achieve enhancement in conversions. In general a reaction to take place the reacting molecules have to come in contact with each other. So when the reagents are present in two phases which are immiscible, then reaction is not at all possible or if at all reaction takes place the reaction is very slow. So for such heterogeneous reactions the use of micro phase will enhance the conversions. Ultrasound has been shown to have desirable effects on both homogeneous and heterogeneous reactions such as increasing the conversion enhancing the selectivity and improving the yield. The enhancements are attributed to chemical effects and mechanical effects. The degradation of the solid reactant, leading to increased surface area have been observed and reported some novel findings effect of ultrasound on mass transfer parameters(1). Microemulsions: induces the super saturation of a sparingly soluble solid in a liquid system(2). Phase Transfer Catalysis (PTC) uses catalytic amounts of phase transfer agents which facilitate inter phase transfer of species, making reaction between reagents in two immiscible phases possible. Mass Transfer effects were analyzed with standard theory of porous catalysts(3). By combining the existing knowledge from chemistry with insights into mechanistic and kinetic analysis, mathematical modeling of soluble and insoluble PTC has been done. The research by these suggested a systematic procedure for modeling these reactions which includes reaction both in liquid and solid phases. Using Microphase as for enhancing the reaction rate has been studied. The size of the carbon particles (Microphase) used are less than the diffusion film thickness, and these will be present in the film. Due to the affinity of carbon particles for organic solutes, they readily adsorb the dissolved ester (which is sparingly soluble in water) from the aqueous film and allow and this increases the specific rate of transfer of the ester from the organic phase to the aqueous phase. The micro phase particles are not true catalysts but enhance rates by strongly adsorbing the organic phase reactant (which is otherwise sparingly soluble in the aqueous phase) and provide for increased contact for reaction between the organic and aqueous phase reactants in the aqueous film(4). Modeling of solid-liquid reactions have been done extensively but there is no single model which caters to all reactions (5;6&7).In our present work, action of micro phase is studied on alkaline hydrolysis of solid esters. We have used Solid ester as Phenyl benzoate and Liquid as NaOH. Microphase as tested Carbon particles Darco G6O(average particle size 4.33 μm.

Experimental Procedure:

The reaction of alkaline hydrolysis of ester (RCOOR') in general could be written as follows.

$$RCOOR' + 2NaOH + H_2O \longrightarrow RCOONa + R'ONa + 2H_2O$$

for Phenyl benzoate the reaction is as follows

$$C_{13}H_{10}O_2 + 2NaOH + H_20 \longrightarrow C_6H_5COONa + C_6H_5ONa + 2H_2O$$

Both the products C_6H_5COONa & C_6H_5ONa are water soluble and stable under alkaline conditions and reaction occur only in the aqueous phase. Experiments were carried out for two particle sizes (75μm and 150 μm) and three concentrations of NaOH (0.21N,0.5N and 1N) . The conversion was calculated from noting the fall in the NaOH Concentration. For experiments with microphase particles the microphase loading was varied from 0.001gm/cc to 0.005gm/cc. All the experiments were carried out in batch mode using magnetic stirrer. All the experiments were carried out until the conversion of solid(phenyl benzoate was about 80-90%.The conversion in absence of microphase particles and in presence of carbon particles is compared.

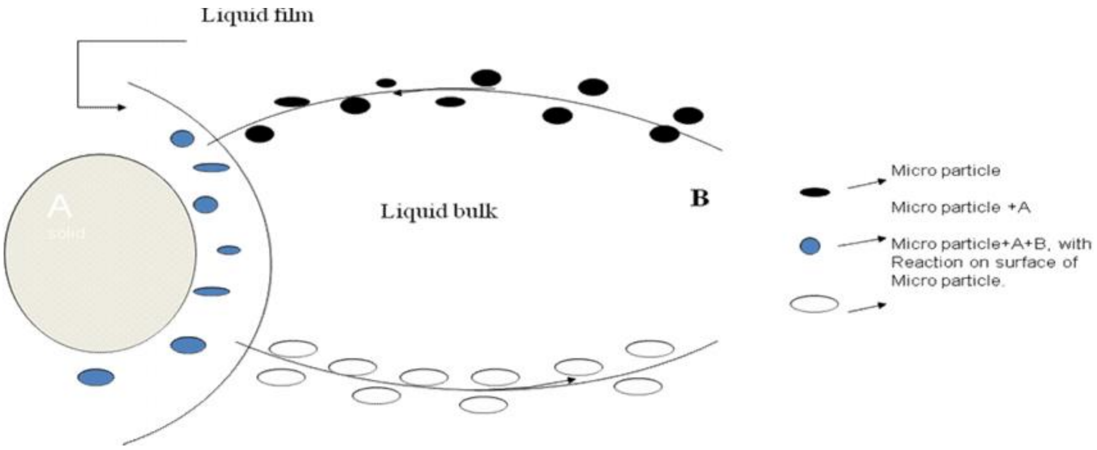

Figure 1Solid-liquid reaction facilitated by micro phase action

Results and Discussions:

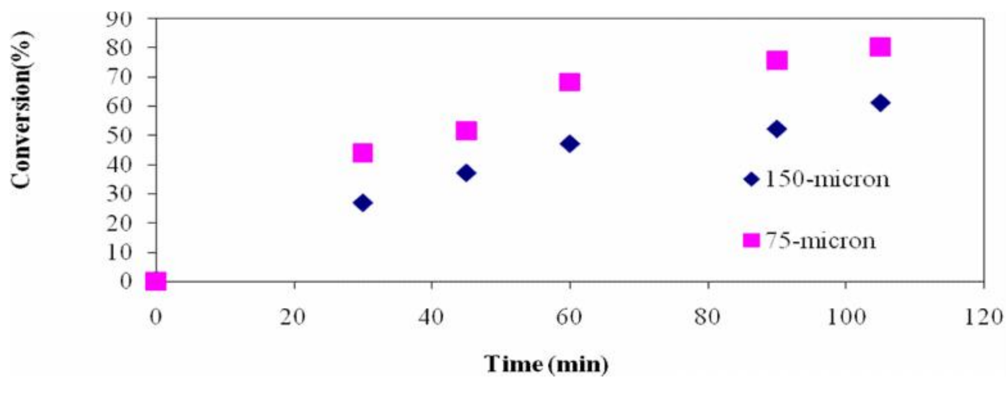

Figure 2 Effect of Solid Particle size on Conversion (CNaOH =1N

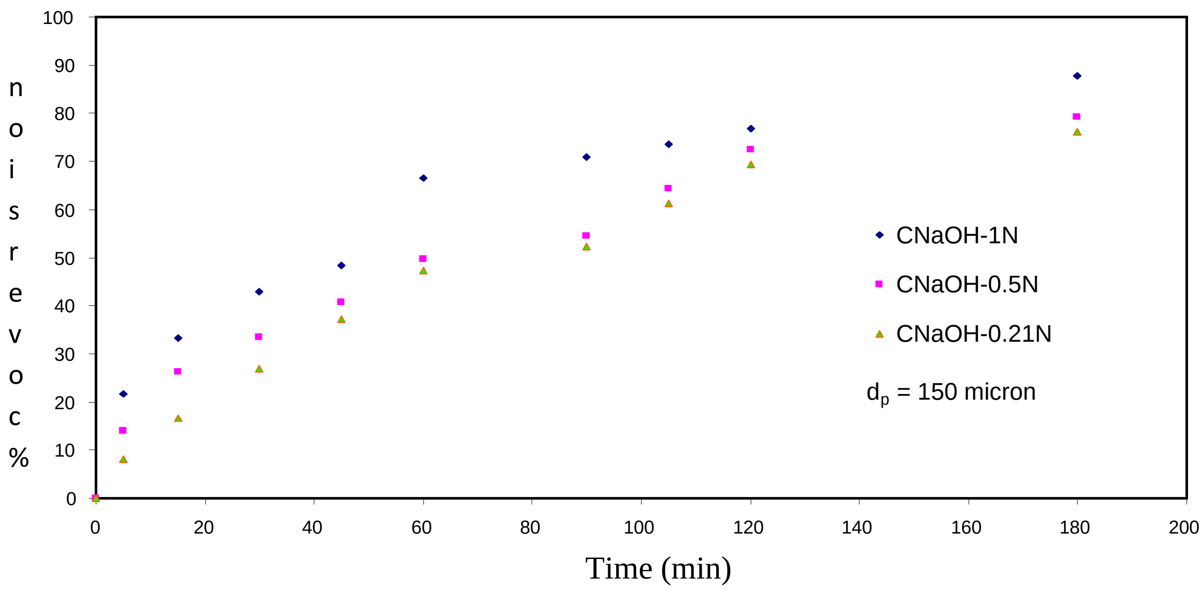

Fig.3 % conversion for 150micron particles for varying concentration of NaOH.

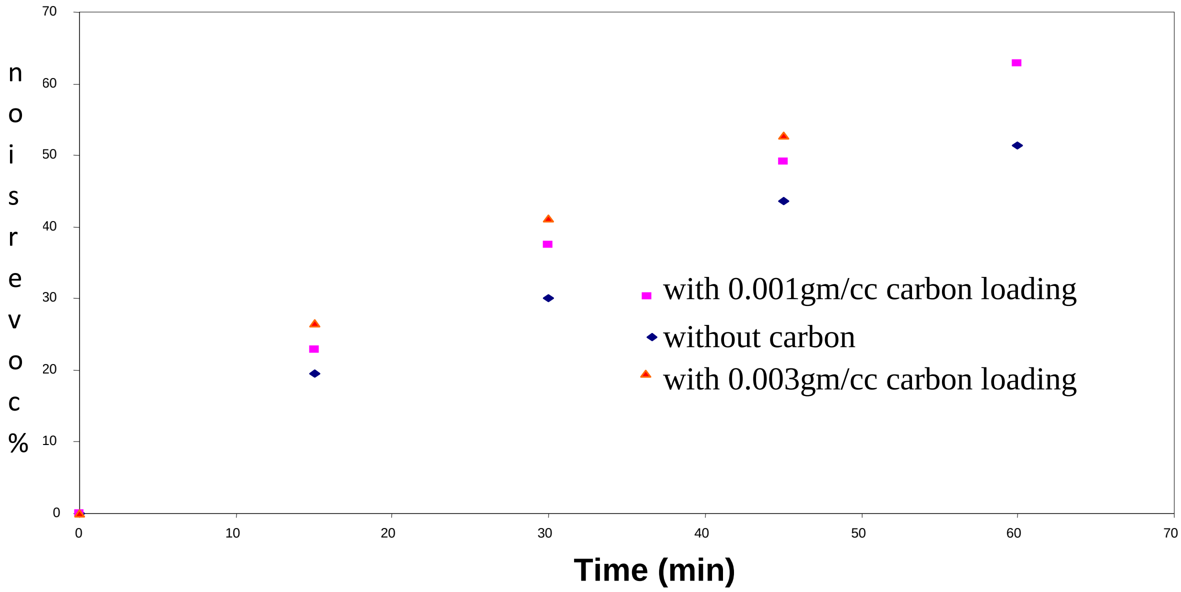

Fig4 Effect of carbon loading

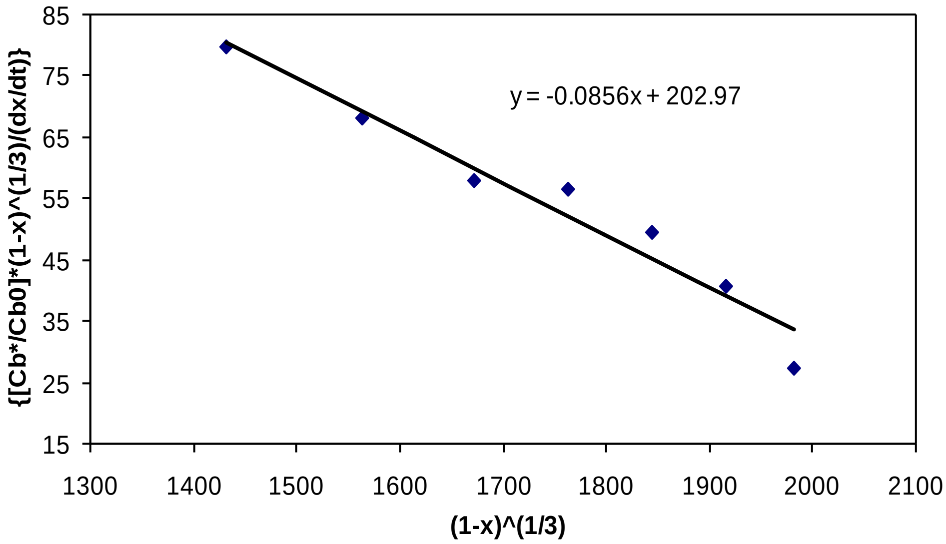

Fig 5 :shows comparioson between experimental data with theoritcal model.

Discussions:

As predicted as the size of the solid particle reduces the conversion rates are higher and similarly as the concentration of liquid increased the conversion rates are increasing. This is contrary to the standard theory of gas-liquid reactions where the concentration of liquid remains constant. As the carbon loading is increased the conversion rates are increasing and beyond certain concentration the conversion rates remains the same. Simple kinetic model was tried to fit the experimental data and the results we would like to present in our next communication.

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