

A Green Technological Route for Catalytic Hydrogenation of Nitrile Butadiene Rubber in a Latex Form

Zhenli Wei, Qinmin Pan and Garry L. Rempel*
Department of Chemical Engineering, University of Waterloo,
Waterloo, Ontario, N2L 3G1 (Canada)
* grempel@cape.uwaterloo.ca

Introduction

The hydrogenation of the carbon-carbon double bonds in nitrile butadiene rubber (NBR) is an important process as the hydrogenated NBR (HNBR) is more resistant than NBR towards oxidative and thermal degradation while maintaining its elastomeric properties in chemically aggressive environments. HNBR has been extensively used for automobile components and oil drilling devices. NBR is synthesized commercially via emulsion polymerization and is available in a latex form. The commercial process for HNBR production involves a number of cumbersome steps, including purifying NBR from the latex, dissolving the NBR in a large amount of organic solvent, and then recovering the organic solvent after the hydrogenation operation [1,2]. It is very desirable to directly hydrogenate NBR in latex form, as such a process would eliminate the need of a large amount of organic solvent and minimize the negative impact on the environment, which is especially important when HNBR in latex form is the desired end-use product. However, while considerable efforts have been made to realize the direct hydrogenation of NBR latex, there has not as yet been reported a successful process in which a conversion higher than 95 % without crosslinking is achieved (95 % conversion without crosslinking in the resultant HNBR is a threshold to ensure the high performance and the excellent processibility of the product). This presentation reports a new approach for successful direct hydrogenation of NBR latex catalyzed by $\text{RhCl}(\text{PPh}_3)_3$.

Materials and Methods

High purity hydrogen was obtained from Praxair Inc. $\text{RhCl}(\text{PPh}_3)_3$ was self-prepared. The NBR latex was provided by LANXESS Inc. Triphenylphosphine (TPP), monochlorobenzene (MCB), methanol and methyl ethyl ketone (MEK) were from Aldrich. The hydrogenation reactions were carried out in a 300 ml autoclave (Parr Instrument Co.). Hydrogenation conversion is obtained via Fourier transform infrared (FT-IR) analysis. The polymer particle size as well as its distribution in the latex before and after hydrogenation was determined at room temperature using a Nanotracs NPA250 particle size analyzer (Microtrac Inc.). Crosslinking was estimated by the amount of the resultant HNBR which is insoluble in MCB at room temperature.

Results and Discussion

Extensive experimental investigation has been carried out with respect to the effects of the ratio of catalyst/NBR, reaction temperature (130-170 °C), hydrogen pressure (250-1000 psi), agitation speed (400-1000 rpm), and NBR content (2-15 wt%) in the latex on the hydrogenation kinetic performance. FT-IR spectrum analyses confirmed that the hydrogenation is completely selective towards the C=C in the latex system at absence of any organic solvent. The results show that the degree of hydrogenation of NBR latex can be higher than 95 % under suitable experimental conditions, that the resultant HNBR latex contains no visible gel and that

the particle size in the latex after the hydrogenation was almost the same as it was before the hydrogenation. The addition of TPP is very beneficial, and the catalyst amount and reaction temperature used in the reaction have major effects on the reaction rate and final conversion. Some typical results are shown in Figure 1 as an example, which indicates the dependence of conversion on reaction time and the effect of the temperature and agitation speed on the conversion and confirmed that the kinetic performance in the latex hydrogenation is close to it in solution hydrogenation [3]; the detailed results as well as the mechanistic analysis will be presented on the conference.

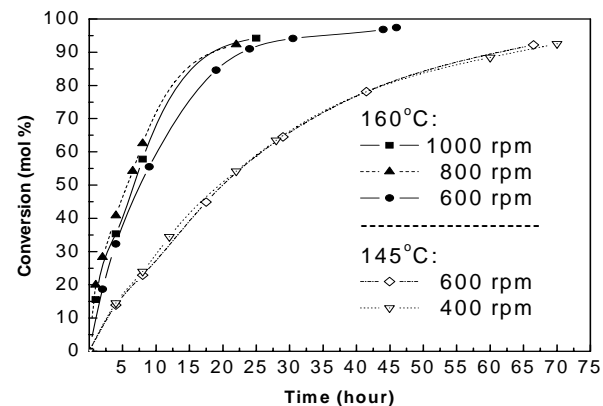


Figure 1 Effect of agitation at 145°C and 160°C on latex hydrogenation (Solid content of Perbunan latex is 15g rubber solid/100ml, Perbunan 25ml, added H₂O 75ml, Rh catalyst/rubber is 1% (w/w), TPP/rubber is 10% (w/w), 1000 psi of hydrogen)

Significance

This is the first time to realize direct hydrogenation of the NBR latex with a conversion higher than 95 % without crosslinking in the resultant hydrogenated product, which implies that the presence of organic solvent associated with the conventional hydrogenation processes can be significantly greened by eliminating the use of such a large amount of the organic solvent and that pretreatment and post-treatment operations can be significantly simplified.

References

1. Mohammadi, N. A., Rempel, G. L. *Macromolecules* 20, 2362 (1987).
2. Rempel, G. L. *Polym. Prepr. (Am. Chem. Soc., Div. Polym. Chem.)* 41, 1507 (2000).
3. Parent, J. S., McManus, N. T., Rempel, G. L. *Ind. Eng. Chem. Res.* 35, 4417 (1996).