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Epoxidation of soybean oil using conventional and microwave heating: a comparative study.

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Highlights

- Epoxidation of soybean oil was studied in absence and in presence of microwave field.
- Sensitivity analysis was performed to obtain the optimal range of the stirring velocity.
- A comparative study demonstrated the beneficial effect of the microwave field.

Abstract

Epoxidised soybean oil (ESBO) is largely used as plasticizer and stabilizer in PVC and, after the interdiction of many phthalates, it represents an optimal sustainable non-toxic alternative. ESBO can be also an intermediate for other products as polyols for the synthesis of polyurethane and polyesters [1,2].

In this paper, the epoxidation of soybean oil was studied in absence and in presence of microwave field. The process conditions were less strong than the usual ones [3]. In fact, 30 wt.% hydrogen peroxide was used instead of 60 wt.% to reduce the risk. Moreover, formic acid was replaced with acetic one, because less corrosive.

The process was studied using two different heating sources. In order to do that, two batch stirred reactors were used, one using microwave, the other employing traditional heating. The two reactors had the same geometry to have the same conditions. In the case of microwave, a proper furnace was used whereas in the other case a thermostatic bath was employed.

First sensitivity analysis of the process in the two cases was performed to obtain the optimal range of the stirring velocity. In this way, the curves yield vs stirring velocity were obtained. Moreover, the conversion vs time plots were obtained in the cases of microwave and traditional heating. Each point of the curves was obtained performing the process at different times. The plots are parametric to the stirring velocity. The analysis were carried out using hydrogen bromide in acetic acid titrations and FTIR spectroscopy.

The results indicate that at low stirring velocity (45 rpm), at 3 hours a noticeably 97% yield can be reached using microwave whereas the case of traditional heating shows a significantly lower yield (less than 10%). At this low stirring velocity, the microwave field can create a good emulsion. In the case of microwave heating, the yield decreases increasing the stirring velocity: the optimum range is at about 40 rpm. This fact can be explained since the impeller promotes the coalescence of the emulsion created by the electromagnetic field. In the case of traditional heating the optimal velocity range is about 450 rpm and the yield is about 85%.

The yield vs time curves indicate for the microwave case that the optimal duration is 3 hours but the process can be shut down at 2 hours because the yield is only 1% lower. The optimal time duration for the traditional process is 3 hours even if the process is slower. In fact, at the early stages of the process (20 minutes), the yield is about 50% for the microwave and the half for the traditional heating. In conclusion, a comparative study on the effect of microwaves was performed and the beneficial effect of the microwave field was demonstrated, both in term of selectivity and rate of reaction.

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Keywords
"Epoxidation oil", "Batch stirred reactors", "Microwave"