

## Green approach to the Isosorbide Conversion into Dimethyl isosorbide

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### 1. Introduction

Isosorbide is one of the most promising products derived from sorbitol. It has already found many applications, mainly in the polymer industry and medicine, such as isosorbide polycarbonate<sup>1</sup> (DURABIO®) and isosorbide nitrates as vasodilator for angina pectoris<sup>2</sup>. The methylation of the two hydroxyl groups of isosorbide molecule gives rise to the formation of dimethyl isosorbide (DMI), which is a high boiling solvent (235°C), used in skin care formulations because of its solubilising capacity and performance enhancing of many different topical skin actives<sup>3</sup>. Currently, DMI synthesis implies the use of methyl halides or dimethyl sulfate. A safer and more environmental benign approach has been proposed by Tundo *et al*<sup>4</sup> by employing dimethylcarbonate (DMC) as both reactant and solvent in the presence of sodium methoxide.

In the present work, the synthesis of DMI in an excess of DMC by using a MgAl mixed oxides (MgAlO<sub>x</sub>), as heterogeneous catalyst, under mild reaction conditions, is proposed.

### 2. Experimental

The MgAlO<sub>x</sub> catalyst derives from a MgAl hydrotalcite with a Mg/Al molar ratio of 3 (Aldrich). The hydrotalcite was undergone to a calcination step at 450°C in nitrogen atmosphere in order to avoid carbonation of the mixed oxides. After this thermal treatment, the MgAlO<sub>x</sub> was put into contact with a solution of isosorbide in DMC, in a batch reactor at atmospheric pressure, under vigorous agitation. The weight ratio catalyst/isosorbide was fixed to 3. Then, the temperature was raised up to 110°C. In order to avoid the evaporation of the DMC, the reactor was cooled with a solution of ethylene glycol at the temperature of -5°C. This experimental setup was carried out in a Carousel 12 Plus Reaction Station™. After 24 hours, the reaction was stopped by immersing the reactor in water, and an aliquot was drawn from the reactor and analyzed by GC coupled to mass spectrometer. Besides, it was evaluated the catalytic activity of MgO and Al<sub>2</sub>O<sub>3</sub> for comparison reasons.

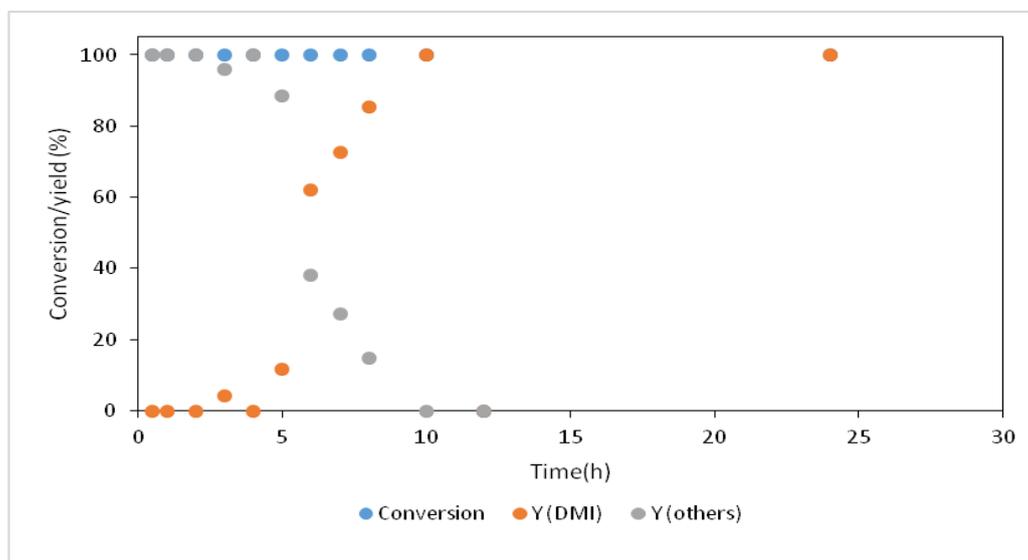
The catalyst was characterized by using techniques, such as XRD, N<sub>2</sub> adsorption, XPS and CO<sub>2</sub>-TPD.

### 3. Results and discussion

The reaction of isosorbide with DMC can originate different products, including those coming from the transesterification (mono and dicarboxymethyl derivatives (DC)) and alkylation (mono and dimethyl isosorbide) processes, as well as carboxymethyl-methyl derivatives (MCE). Moreover, different isomers of these compounds can be also formed, and others products such as methanol and CO<sub>2</sub>.

First, it was evaluated the influence of the reaction time on the catalytic performance of the MgAlO<sub>x</sub> catalyst. The Figure 1 shows that the isosorbide is almost completely consumed in the first 30 minutes of reaction.

Moreover, the isosorbide was mainly converted into DC and in a minor proportion of MCE. No other compounds were detected after 30 min. When the reaction progresses, the DMI yield increases notably after 6 hours, and finally, the complete conversion of isosorbide into DMI is accomplished after 10 hours. It is noteworthy mentioning that the only products detected were DC, MCE and DMI. The evolution of such compounds follows the trend: DC is first formed at short reaction time, and then this compound was converted into the MCE, increasing its concentration progressively, and, at the same time, DMI starts to be formed from both DC and MCE, which is more pronounced from the 6 hours of reaction.



**Figure 1.** Evolution of DMI yield and isosorbide conversion as a function of the reaction time, at 110°C.

The influence of reaction temperature was also evaluated (Table 1). The isosorbide conversion was always of 100% but temperatures higher than 90°C are necessary to reach a substantial DMI yield.

**Table 1.** Influence of temperature reaction after 24 hours of reaction.

Temperature (°C)	Isosorbide Conversion (%)	DMI Yield (%)
90	100	1
100	100	61
110	100	100
120	100	88

#### 4. Conclusion

In this work, it is demonstrated that it is possible to convert completely isosorbide into DMI by basic heterogeneous catalysis in mild conditions.

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