Photo-epoxidation of Propylene to Propylene Oxide over V-Ti/MCM-41: A Wavelength Effect on Photocatalytic Activities

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Abstract

Direct photocatalytic epoxidation propylene was studied using three different UV filters (365, 320-500 and 250-400nm). The energy of light irradiation is sufficient to activate oxygen and/or propylene and promote photocatalytic epoxidation over V-Ti/MCM-41. Among the three UV filters, the highest photocatalysis \( \text{C}_3\text{H}_6 \text{conv.} \) was obtained at 250-400nm while PO formation rate and PO selectivity were achieved highest at 320-500nm.

Keywords: epoxidation, propylene oxide, photocatalyst, V-Ti/MCM-41, wavelength effect.

Introduction

Propylene oxide (PO) are used to produce a numerous commercial materials which are used in many consumer applications (Fig.1).

![Fig.1: Consumer application of PO chemical intermediates](image)

However, there is only a few researches focus on photo-epoxidation and their performances are not advanced yet due to the formation of partial and total oxidation (Fig.2).

![Fig.2: Reaction pathways of propylene in the selective propylene epoxidation](image)

Herein, this study will evaluate the direct photo-epoxidation under separate wavelengths illumination (Eq.(1)) over V-Ti/MCM-41 which was synthesized by simple hydrothermal treatment method.
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\begin{align*}
\text{C}_3\text{H}_6 + \frac{1}{2}\text{O}_2 & \xrightarrow{\text{UV light}} \text{V-Ti/MCM-41} \\
& \rightarrow \text{CH}_3 - \text{CH} - \text{CH}_2 \\
\end{align*}
\]

\(\text{Eq.(1)}\)

**Results and Discussion**

Mercury Arc light was guided by an optical fiber to the photo-reactor. The feed gas was analyzed periodically using YL6100 GC equipped with FID and TCD(Fig.3).

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XRD confirmed the family of mesopore structure of catalyst while UV-vis absorption edge confirmed the tetrahedral environment of isolated framework Ti\(^{IV}\) centers.

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2. Effect of wavelengths

The remarkable improvement of C$_3$H$_6$ conv. rate due to the enhancing electron-hole generation rate with increasing energy of radiation. In addition, excess amount of electron-hole pairs may cause a secondary reaction in photo-epoxidation so PO could further transformed to other intermediate products(Fig.7).

On the whole, when 365nm was switched to 250-400nm, C$_3$H$_6$ conv. rate was enhanced while the PO selectivity was still very stable. The C$_3$H$_6$ conv. rate gradually decreased on stream due to high amount of intermediates were produced and deposited on the surface of catalyst(Fig.8).

The more photons are excited by light irradiation, the more conversion of C$_3$H$_6$ can be achieved. However, it will make the PO selectivity decreasing(Fig.9).
Conclusion

1. The feasibility of using UV irradiation with V-Ti/MCM-41 in photocatalytic epoxidation propylene to PO was evaluated by comparison three UV filters (365, 320-500 and 250-400nm).
2. It is strongly suggested that the energy of light irradiation is sufficient to activate oxygen and/or propylene and promote photocatalytic epoxidation of propylene over V-Ti/MCM-41.

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Reference