P27 Using the AMOST procedure to prepare layered hydroxide $Mg_3Al_{1-x}Ti_x$ as low-cost and high-performance De-NOx photocatalysts.

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Extended Abstract

Summary

The layered double hydroxides (LDHs), due to their structural properties and their low cost, are promising photocatalysts for NO_x gases removal. We prepared different highly dispersed MgAlTi layered double hydroxide ($Mg_3Al_{1-x}Ti_x$-LDH) using the aqueous miscible organic solvent treatment (AMOST). The effect of the organic solvent, acetone or ethanol, in the delamination process was studied. The samples were characterised with XRD, FT-IR and HRTEM, and then we analysed their ability to eliminate nitrogen oxides from air through a photochemical oxidation process. The results showed that the $Mg_3Al_{0.8}Ti_{0.2}$ -LDH treated with acetone has the best DeNOx activity.

Background

Nitrogen oxides gases (NO_x = NO + NO_2) emissions in urban atmosphere exceed the limits recommended for human health. Because of that fact, high attention has been paid to the development of strategies to removal NOx from the air. Between them, photocatalysis is one of the most promising remediation of this problem. In addition, LDHs are highly proficient for the photocatalytic abatement of NO_x gases thanks to their unique structure and simple synthesis [1].

Previous studies indicate that AMOST method leads to the preparation of LDH nanosheets which, thanks to their large surface area, exhibit outstanding $DeNO_x$ efficiency and selectivity [2].

Methodology

The MgAlTi-LDH was obtained by the co-precipitation method with $Mg^{2+}/(Al^{3+} + Ti^{4+}) = 3$ and $Ti^{4+}/Al^{3+} = 0; 0.25; 1; 4$. A 1M solution of metal salts was added dropwise into 100 mL of 1.5 M $Na_2CO_3 \cdot 10H_2O$ solution under stirring at room temperature, and the pH value was kept at 10 by dropwise addition of NaOH solution. After aging for 16h with stirring, the mixture was washed with distilled water and filtered [3].

In this moment, the samples synthetised this the conventional method were dried at 60 ˚C (named as $Mg_3Al_{1-x}Ti_x$-LDH-W). For the samples prepared with AMOST method, the wet cake obtained in the filtration step, was dispersed in organic solvent, filtered, and dried at 60˚C. These samples were dispersed with ethanol or acetone, labelled as $Mg_3Al_{1-x}Ti_x$-LDH-E or $Mg_3Al_{1-x}Ti_x$-LDH-A respectively, during a determined period.

The obtained samples were characterised using XRD, nitrogen adsorption-desorption isotherms, XRF, FT-IR, UV-Vis, and HRTEM. Finally, the photocatalytic process was performed in a quartz window in a continuous flow photoreactor, which was placed inside a solar simulator with irradiance 28 and 230 W/m^2 for UV and visible light, respectively.

Results and Discussion

The X-ray diffraction (fig. 1) shows the characteristic pattern of LDH, indicating that the structure is preserved during the AMOST treatment. We observed that the incorporation of Ti^{4+} causes less intense diffraction peaks. Furthermore, the samples dispersed with acetone exhibits the broadest and lowest reflections, indicating less extent of layer stacking.

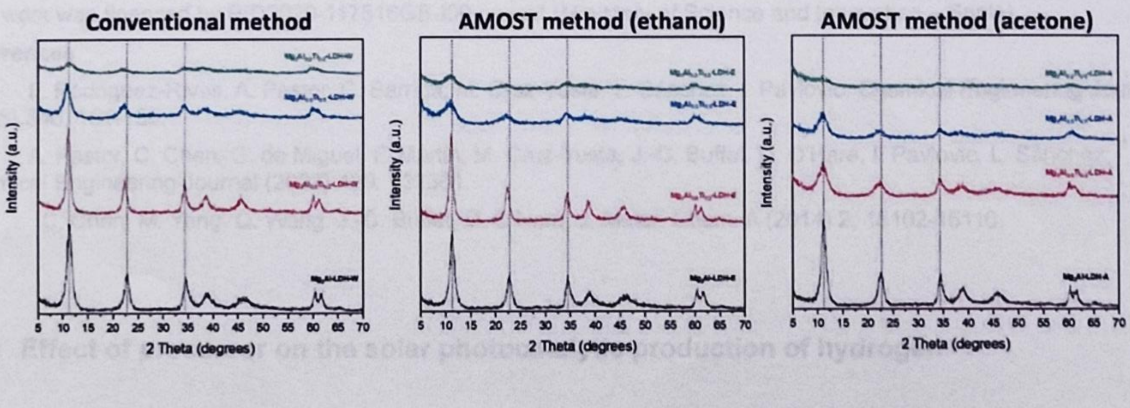

Figure 1. DRX of $Mg_3Al_{1-x}Ti_x$-LDH. $Mg_3Al_{0.2}Ti_{0.8}$-LDH (green), $Mg_3Al_{0.5}Ti_{0.5}$-LDH (blue), $Mg_3Al_{0.8}Ti_{0.2}$-LDH (red), Mg_3Al-LDH (black).

The FT-IR spectra shows the characteristic bands of LDH corresponding to the O-H bonds stretching vibration and bending models of water molecules, the vibration mode of carbonate, and the M-O vibrational bending models. These findings confirm the formation of the LDH structure.

In the UV-Vis spectra of LDH, the absorption region appears in the UV region (200-400 nm), and it increases with Ti^{4+} dopping. For this reason, the photocatalytic process was evaluated under UV light. In the figure below, we can observe the high improvement in NO removal when the LDH contains Ti^{4+} in their structure.

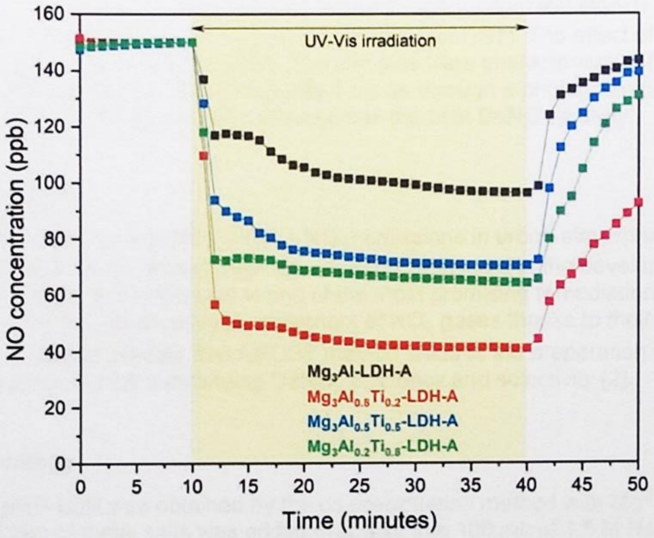

Figure 2. Photocatalytic test comparison of $Mg_3Al_{1-x}Ti_x$-LDH

Conclusions

- The MgAlTi-LDH De-NOx photocatalyst is easily prepared by using the AMOST procedure.
- The Ti^{4+} incorporation in the LDH structure increases the ability to absorb UV light and its specific surface area.
- The properties provided by Ti^{4+} dopping to the MgAl-LDH create structures with remarkable photocatalytic efficiency.
- The sample with the best DeNOx performance is $Mg_3Al_{0.8}Ti_{0.2}$-LDH-A, with a NO abatement of 70%, similar to that of TiO_2-P25 commercial product.

Keywords

Layered double hydroxide; NO; AMOST; photocatalysis.

Acknowledgements

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References

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P28 Effect of precursor on the solar photocatalytic production of hydrogen