Catalytic Activity of AlF_3 Nano-Structure for Hydrolysis of NF_3

Yong Han Jeong[1], No-Kuk Park[1], Tae Jin Lee[1], Won Chul Chang[2]
[1]*School of Chemical Engineering, Yeungnam University, Gyeongsan, Korea*
[2]*HMPNC Co. Ltd., Seoul, Korea*

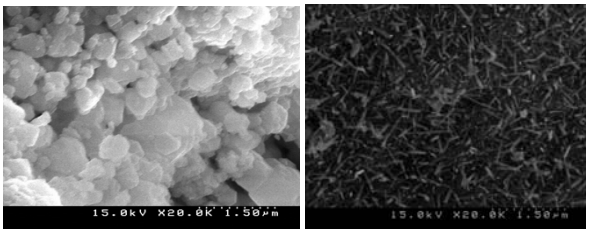
*E-mail: tjlee@ynu.ac.kr

Recently, the climate has been changing rapidly due to global warming. Fluorine compounds have also been highlighted as a warming gas that affects climate change. Perfluoro-compounds are commonly used in the semiconductor and LCD manufacturing industries. The atmospheric lifetime and global warming potentials (GWP) of NF_3 are 740 year and 17,200 (relative to CO_2), respectively [1]. In addition, the production and use of NF_3 is concentrated in the Republic of Korea [2].

Solid acid catalysts, such as zeolites, γ -Al_2O_3, SiO_2-Al_2O_3, V_2O_5/Al_2O_3, TiO_2-SiO_2, and CrO_3/ZrO_2, are used in decomposition of fluorine compounds like NF_3 [3]. The catalysts converted to metal fluoride lose their catalytic properties in most cases but some studies have reported metal fluoride catalysts [4].

In this study, AlF_3 catalysts, which is a metal fluoride, were used for the decomposition of NF_3 exhausted in the semiconductor manufacturing process. AlF_3 nano-structures of various morphologies, which were synthesized by a range of synthesis methods. In addition, the reaction characteristics and catalyst characterization according to their morphology were analyzed.

This study evaluated catalytic hydrolysis for the effective decomposition of NF_3. AlF_3 nano-structures with various morphologies, which were synthesized by a range of synthesis methods, were used as the catalyst for the hydrolysis of NF_3. AlF_3 with a nano-needle type morphology was synthesized by a gas-solid reaction, and AlF_3 with a large-sized rod type morphology was synthesized using the wet chemical method. The catalytic activity tests were carried out in a fixed-bed reactor and the content of NF_3 and GHSV were fixed to 5000 ppmv and 15000 h^{-1}, respectively. A volumetric ratio of NF_3/H_2O was fixed 1/3 for hydrolysis of NF_3. On the other hand, the results of the activity tests for the hydrolysis of NF_3 over AlF_3 with different morphologies exhibited different catalytic activity. In contrast, the catalytic activity of needle-shaped AlF_3 resulted in 100% NF_3 conversion. The activity was maintained for more than 300 h in the long-term tests. The hexagonal structure of AlF_3 has higher catalytic activity for the hydrolysis of NF_3 than the orthorhombic structure of AlF_3. Although the hexagonal structure of AlF_3 had a high catalytic activity for the hydrolysis of NF_3, the needle-like shaped hexagonal structure of AlF_3 had higher catalytic activity than the other shaped hexagonal structures.



Commercial Nano-needle

Fig.1 SEM images of AlF_3 nanostructures.

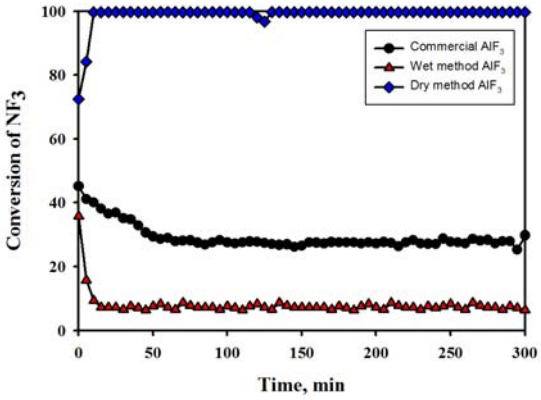


Fig. 2 Conversion of NF_3 over various AlF_3 nano-structures.

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