Catalytic Activity of AlF₃ Nano-Structure for Hydrolysis of NF₃

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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 NF₃ are 740 year and 17,200 (relative to CO₂), respectively [1]. In addition, the production and use of NF₃ is concentrated in the Republic of Korea [2].

Solid acid catalysts, such as zeolites, γ-Al₂O₃, SiO₂-Al₂O₃, V₂O₅/Al₂O₃, TiO₂-SiO₂, and CrO₃/ZrO₂, are used in decomposition of fluorine compounds like NF₃ [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, AlF₃ catalysts, which is a metal fluoride, were used for the decomposition of NF₃ exhausted in the semiconductor manufacturing process. AlF₃ 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 NF₃. AlF₃ nano-structures with various morphologies, which were synthesized by a range of synthesis methods, were used as the catalyst for the hydrolysis of NF₃. AlF₃ with a nano-needle type morphology was synthesized by a gas-solid reaction, and AlF₃ 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 NF₃ and GHSV were fixed to 5000 ppmv and 15000 h⁻¹, respectively. A volumetric ratio of NF₃/H₂O was fixed 1/3 for hydrolysis of NF₃. On the other hand, the results of the activity tests for the hydrolysis of NF₃ over AlF₃ with different morphologies exhibited different catalytic activity. In contrast, the catalytic activity of needle-shaped AlF₃ resulted in 100% NF₃ conversion. The activity was maintained for more than 300 h in the long-term tests. The hexagonal structure of AlF₃ has higher catalytic activity for the hydrolysis of NF₃ than the orthorhombic structure of AlF₃. Although the hexagonal structure of AlF₃ had a high catalytic activity for the hydrolysis of NF₃, the needle-like shaped hexagonal structure of AlF₃ had higher catalytic activity than the other shaped hexagonal structures.

REFERENCES