Flue gas DeNOx with SILP

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ABSTRACT

The main component of atmospheric air is nitrogen. During combustion at high tempatures, nitrogen can undergo oxidation, thus making nitrous oxides (NOx gasses). This occurs frequently when atmospheric air is used as oxygen supply for combustion processes, whether it be in coal, biomass or oil fueled power plants, combustion engines for transportation, or other combustion processes.

Especially the NOx gasses, NO_2 and NO are toxic, and harmful to the environment. These gasses make acid rain, and contribute to depletion of the ozone layer.

This project focuses on flue gas DeNOx from smaller sources, such as diesel engines. Processes are already in use for DeNOxing flue gas from power plants and gasoline engines. For gasoline engines, a three way catalyst is used, this cannot however be applied to diesel engines, due to a much higher oxygen content in the exhaust gas. The process used in power plants is called SCR (Selective Catalytic Reduction) and uses concentrated ammonia and a catalyst to reduce the NOx gasses into harmless nitrogen. The process demands a big reactor, and concentrated ammonia, which is both a major health risk and environmental risk in case of accidents.

This project explores the opportunity of installing an efficient DeNOx unit in the exhaust of a diesel engine, thus cleaning the flue gas. The DeNOx unit will consist of a SILP (Solid Ionic Liquid Phase) absorber. The SILP absorber is made up of porous particles and an ionic liquid, in this case $[BMIM]NO_3$. The porous surface creates a large surface area on which the reaction can occur.

The SILP uses the excess air and water in the flue gas, to convert the NOx into nitric acid, which is captured and stored in the ionic liquid. Tests were conducted by exposing a SILP reactor to a simulated flue gas mixture. The NOx concentration was monitored by a UV-VIS Spectrometer.

The spectrometer was set to obtain a spectrum at wavelengths from 250 nm, to 200 nm. At these wavelengths it is possible to monitor NO and NO_2 simultaneously. The results clearly state that it is possible to remove all of NO and NO_2 for a significant period of time.

When the maximum capacity of the SILP is reached, it is possible to simply desorb the nitric acid from the SILP, by heating it to a temperature above 80ºC, in a stream of gas. The capacity of the ionic liquid in the SILP is around 1.05 moles of HNO_3 per mole of ionic liquid, at room temperature. Even though the maximum capacity of the ionic liquid is lowered at higher temperatures, the conversion of NOx to nitric acid becomes faster.

The SILP is reusable, and there is no apparent drop in capacity when reusing the SILP. The nitric acid that is produced from the reaction can be obtained, and used in the chemical industry. Nitric acid is one of the most produced chemicals in the world, and this technology will thus be able to both reduce the NOx emission from transportation, while lowering the amount of nitric acid produced in the chemical industry each year.