

Nitric acid production from off-gases by green and sustainable catalysis

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ABSTRACT

Air pollution is a major concern with respect to global warming, public health and other environmental hazards. Furthermore, the combustion of fossil fuels is known to contribute significantly to global warming. These concerns have given rise to both increased need for sustainable flue gas cleaning methods and alternative CO₂ neutral fuel resources.

Nitrogen oxides (NO_x) are gas species that form when burning fuels with air at high temperatures or when burning nitrogen-rich fuels like biomass or household waste. If these species are released to the environment, they contribute directly to the greenhouse effect and cause acid rain. The conventional way of removing NO_x species is by selective catalytic reduction (SCR) with ammonia at temperatures around 300 °C. The catalysts used at power plants are toxic and harmful to the environment. Mobile units such as trucks and ships also emit NO_x species. The ammonia source used is an aqueous solution of urea, since ammonia is more hazardous to transport and store. The use of chemicals to reduce NO_x emissions causes challenges due to space requirements on these mobile units.

Studies have shown that ionic liquids (ILs) possess great absorption capacity of different gasses at low temperatures. Furthermore, some ILs absorb NO_x with great selectivity and in the presence of air and water, the NO_x species can be oxidized to nitric acid. The IL can be dispersed on a support material to reduce mass transport limitations, the so-called Supported Ionic Liquid-Phase (SILP) materials. These non-toxic materials can be used instead of the traditional catalysts. This method eliminates the use of additional chemicals and provide an economical enticement towards green flue gas cleaning. Furthermore, SILP materials has optimum absorption capacity at low temperatures below 100 °C, eliminating the need to reheat the flue gas and is energy efficient.

A dual reactor system has been proposed where the SILP catalysts are implemented in the reactors. (Riisager et al., 2014) The flue gas is let trough one reactor at 40 °C so that the NO_x will be absorbed. When the SILP is saturated with NO_x, an air flow is subsequently let trough the reactor at 130 °C in order to desorb nitric acid and let to stock. When the flows are switched, the other reactor will start absorbing NO_x from the flue gas. With this dual reactor system, the waste (NO_x) is continuously formed to a product of commercial value.

In order to improve the efficiency of the system, a preoxidation reactor could be added. This reactor oxidize the lower NO_x species to higher NO_x species with another type of SILP material and therefore provides a significantly faster reaction in the dual reactor. This preoxidation step has been studied, showing great efficiency when utilizing solvent effects. The preoxidation step could also be implemented in already existing processes, such as the fast SCR process.

The system, if implemented, can be of great advantage in waste incineration plants and when using biomass as fuel, where the traditional methods has limitations due to poisoning of the catalyst. On ships, which are major pollutants, the system could also be implemented. The ships would then produce nitric acid at sea and sell this product when in port instead of having the need to buy chemicals.

Reference: Riisager, A., Mossin, S., Madsen, A. T., Kunov-Kruse, A. J., Thomassen, P., & Fehrmann, R. (2014). *Combined oxidation and absorption of NO_x by an ionic liquid tandem process* (Patent application).