

Thermal Plasma Catalytic System for Fast Synthesis of Nitrogen Fertilizer from Air and Water

Nitrogen forms the most vital organic compounds of life like amino acids, proteins, nucleoside triphosphates, the molecular precursors to nucleic acids DNA and RNA. In spite of nitrogen being highly abundant in atmosphere, it cannot be directly used by most of the living organisms. The strong triple covalent bond makes it to behave mostly like an inert gas. Nitrogen needs to combine with some other elements to form functional compounds like ammonia, nitrate or nitrite usable by living beings.

Industrial nitrogen fixation methods mostly use Haber-Bosch process as the most dominating industrial practice where nitrogen is fixed in the form of Urea. The process uses fossil fuel and hence not sustainable. It is not decentralizable due to requirement of heavy installations related to high temperature and high pressure. It also has adverse environmental effects due to emission of thousands of tons of greenhouse gases like CO₂. A primary issue, often oversighted, is the fact that ammonia being gaseous, more than 50% of applied fertilizer nutrients in urea simply gets lost to the atmosphere. Practically, it is only 17% of the applied nitrogen in the fertilizer that finally gets used by the agricultural products. Loss of fertilizer to aquatic world may lead to algal boom and may severely hamper biodiversity.

The study presents a newly developed novel thermal plasma based compact portable catalytic system for fast synthesis of nitrate and nitrite. The system offers single-step ultra-fast high throughput synthesis at atmospheric pressure under nascent plasma condition with minimal waste production as compared to traditional wet chemistry processes. It requires significantly lower capital investment for small scale, decentralized fertilizer production and has the compatibility to work with intermittent renewable energy. Its ability to operate with renewable energy sources, independent of fossil fuel has the potential to secure enhanced stability in fertilizer price and food price. On-site production of nitrate and nitrite fertilizer using atmospheric N₂ and readily available abundant H₂O on earth as feed stocks eliminates the emission of CO₂, as well as costs associated with transportation of feed stocks and fertilizer distribution. Fast synthesis, operability with renewable energy, zero CO₂ emission, feasible small-scale distributed production and less capital investment are the key features of the developed system discussed.

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