An innovative technique for the sustainable production of pure nitric oxide

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Introduction

NO plays a wide variety of roles in biological organisms like vasodilation in blood vessels, immune system, penile erection, neurotransmission and many other functions specially in response to injuries, infection and cell growth of skin [1].
Gaseous nitric oxide (gNO) is an FDA approved drug for treatment of many maladies and illnesses like Pulmonary Hypertension in the full term infant and non-healing lesions and fungal dermatophyte infections. Likewise, other therapeutic potential of gNO addresses treatment of some disorders in human and animal body as a vasodilatation agent [2].
Unfortunately, known methods of production of pure gNO suffer from many disadvantages like high cost, complexity of gas delivery, environmentally unfriendly and toxic byproducts [3]. The other significant problem is storage of gNO. Since NO is thermodynamically an unstable molecule, it readily reacts with traces of O_2 to form NO_2 and N_2O if compressed. Therefore, gNO has inherently short shelf life.
In view of the need of pure gNO and the challenging barriers facing its production, the present work introduces an original, inexpensive, safe and very simple catalytic technique to produce gNO.

Materials and Methods

$BaO/\gamma\text{–}Al_2O_3$ (16/100 w/w) samples were prepared by incipient wet impregnation of a commercial γ–alumina support (Versal 250 from La Roche Chemicals) calcined at 700°C. Barium acetate was used as precursor (Sigma-Aldrich 99%). After impregnation the powders were dried overnight at 80°C in air and calcined at 500°C for 5 h [4]. The catalyst powder was sieved to 140–200 mesh and loaded (51.5 mg) in a flow-micro reactor consisting of a quartz tube (6 mm i.d.) placed in an electric furnace in order to guarantee isothermal operation. The species concentrations in the reactor outlet stream were continuously monitored by a UV analyzer (ABB-LIMAS 11 HW). NO production experiments were performed with a NO_2 feed concentration of 500 ppm in a base feed stream consisting of balance Helium. The system was operated at atmospheric pressure with Gas Hourly Space Velocity (GHSV) of about 83,000 $cm^3/h/g_{cat}$.

Results and Discussion

In this work, $BaO/\gamma\text{–}Al_2O_3$ is employed to adsorb NO_2 while releasing pure NO according to the following global reaction, well known in Lean DeNOx catalysis [5]:

$$3NO_2 + BaO \rightarrow Ba(NO_3)_2 + NO \qquad \text{R.1}$$

The overall stoichiometry of R.1 shows the release of one molecule NO for the consumption of three molecules of NO_2, while stable nitrates are left on BaO. This stoichiometry is confirmed by our experiments, wherein the produced NO was found equal to one third of the reacted NO_2 within ±5%.

One representative NO_2 adsorption run is shown in **Figure 1**. After starting the test, for more than 30 minutes no NO_2 was detected by the UV analyzer, while the first trace of NO was detected after 3 minutes. The data in **Figure 1** indicate that 1 gram of the prepared catalyst was able to produce 2e-4 moles of NO before Breakthrough Point (BTP). BTP is defined as the time when the NO_2 concentration at the reactor outlet started to exceed 2 ppm.

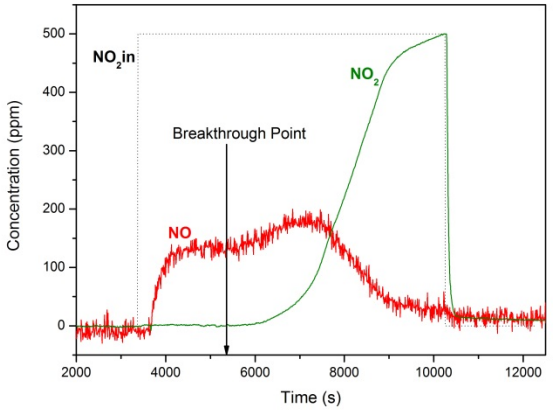

Figure 1. NO_2 adsorption and NO production on $BaO/\gamma\text{–}Al_2O_3$ at room temperature. Feed = 500 ppm NO_2 and balance He, T-ads = 26°C, GHSV = 83,000 $cm^3/h/g_{cat}$

The saturated bed was then fully regenerated in a temperature ramp (20 °C/min) up to 550°C, releasing adsorbed nitrates in the form of NO and NO_2. In principle, the NOx released from the reactor during the regeneration stage can be recovered, while NO production can be carried out in another catalytic bed in parallel arrangement with the first one.

Significance

We show that a catalytic bed of barium on alumina is able to convert efficiently NO_2 to pure NO for a significant time interval before NO_2 breakthrough. This seems a promising approach for pure NO production from a stable source (NO_2), which could solve in principles issues associate with the difficult storage and transportation of pure NO.

References

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