Reproduzierbare Versuche? – Entwicklung und Charakterisierung eines innovativen Parallelreaktorsystems

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Ob Ausgangsstoff, Zwischenprodukt oder Endstufe – jedes chemische Erzeugnis erfordert eine Syntheseroute. Sticht ein Verfahren durch ressourcenschonende Eigenschaften hinsichtlich Rohstoff-, Hilfsmittel- und Energieverbrauch oder durch eine kürzere Reaktionszeit hervor, so sind damit in der Regel Verbesserungen bezüglich der Ökonomie und auch der Ökologie verbunden. Komplexbildende Katalysatoren werden aus diesem Grund seit dem Anbeginn der technischen Chemie industriell eingesetzt. Daher beruht eine Vielzahl aller im Portfolio der chemischen Industrie angebotenen Erzeugnisse auf dem Einsatz von Katalysatoren.

Auf dem Gebiet der Katalyse nimmt der Bereich der heterogenen Katalyse mit den damit verbundenen Vor- und Nachteilen einen immer grösser werdenden Stellenwert ein.[1] Die heterogene Katalyse zeichnet sich durch ein geringeres Mass an unerwünschten Nebenkomponenten aufgrund nicht vorhandener Liganden oder aufkommende Herausforderungen bei der Isolierung aus dem Reaktionsgemisch aus.

In dieser Arbeit wurde ein Parallelreaktorsystem für heterogen katalysierte, dreiphasige Reaktionen geplant, aufgebaut, in Betrieb genommen und charakterisiert. Das Ziel besteht in der kurzfristigen Bereitstellung einer kleinvolumigen Reaktionsapparatur, welche die parallele Durchführung von bis zu sechs Reaktionen gleichzeitig zulässt. Der primäre Einsatzzweck dieser Apparatur ist die Aktivitätsuntersuchung und -beurteilung unterschiedlicher Katalysatoren. Das massgebliche Beurteilungskriterium ist dabei die Erzeugung reproduzierbarer und stabiler Messergebnisse. Um dies zu erreichen, sind genaue Kenntnisse über die Stoff- und Wärmeübertragungskoeffizienten notwendig. Im Hinblick auf den Stoffübergang ist es zweckmässig, eine Unterscheidung zwischen dem Mischverhalten des eingesetzten Rührertyps und dem resultierenden Stoffübergangskoeffizienten des zudosierten Gases in die Lösung zu treffen. Mit einer ausgewählten Modellreaktion[2] wurde die Anlagencharakterisierung durchgeführt. Der Einfluss verschiedener Prozessparameter wie die Rührergeometrie, die Rührerdrehzahl, die Begasungsrate und die Blasengrösse wurden auf den kL·a - und k-Wert untersucht und mit den Versuchsergebnissen der Modellreaktion in Korrelation gesetzt.

In übersichtlicher Darstellung werden auf dem Poster neben dem realen und schematischen Aufbau der Nachweis der Reproduzierbarkeit erbracht und die Ergebnisse der Charakterisierung erläutert.

[1] G. Prieto, F. Schüth, *Angew. Chem.* **2015**, *127*, 3268.
[2] S.Ueda, H.Nagasawa, *J. Am. Chem. Soc.* **2009**, *131*, 15080.

Exhaust Air Cleaning System from Corn Stover for Reducing Ammonia Emissions from Livestock Housing

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Abstract: Ammonia emissions from animal facilities have a negative impact on environment and human health. This study develops an air cleaning system from corn stalk impregnated with phosphoric acid to recover ammonia emissions from poultry facilities and produce nitrogen fertilizer. The prototype tested in a poultry facility showed an abatement of >95% of ammonia emissions.

Keywords: Agriculture · Ammonia · Emission · Exhaust air cleaning · Reduction

Introduction

For 25 years, emissions of major air pollutants have significantly reduced except for ammonia. In Switzerland, these emissions are allocated to 90% in agricultural activities, mainly by farm livestock.[1] Ammonia emissions are due to biological decomposition of manure. Since ammonia has a negative impact on animal health, poultry and swine production facilities are ventilated to maintain indoor ammonia level below 25 parts per millions. Gaseous ammonia combines then with the acidic gas species in the atmosphere to form PM2.5 and PM10 particulate matter which can affect human health.[2] Ammonia can also be carried by wind over long distances and contributes to over-fertilization. The consequences are eutrophication and acidification of soils and biodiversity loss. Ammonia emissions from agriculture are estimated at 48,000 tons per year.[3] The soil nitrogen cycle has important losses which must be compensated by the use of industrial fertilizers. Although Switzerland has reached the 2010 targets of the Gothenburg Protocol for the reduction of ammonia emissions (–17% as compared to 1990),[3] progress remains insufficient to achieve the new objectives for 2020. For this, the Swiss Federal Council defined the goal to reduce ammonia emissions by about 40% compared to 2005.[4]

Actually the Ordinance on Air Pollution Control (OAPC) states that emissions shall be limited as far as is technically and operationally feasible and economically acceptable (*art. 4 OAPC*). Nowadays, the exhaust air cleaning systems available commercially work as a chemical scrubber. Exhaust air is treated by sprinkling and the washing water is continuously acidified with sulfuric acid to maintain a pH of about 3. This method offers a partial solution. The system allows the reduction of ammonia emissions with efficiency up to 70%, but it is expensive, cumbersome, requires a lot of maintenance and produces a large amount of sludge to be recycled.[5]

Corn Stover for Reducing Ammonia Emissions

In order to solve this problem, the company Sorba Absorber GmbH and the School of Engineering and Architecture of Fribourg, with the collaboration of the Canton of Fribourg (CleanTech Fribourg) and the Federal Office for the Environment (FOEN), developed a new air cleaning system from corn stover impregnated with phosphoric acid. Because ammonia is highly soluble in acidic medium, it is washed out and trapped chemically with phosphoric acid to give ammonium phosphate (Eqn. (1)), a fertilizer commonly used for crop production. The used filter material could be recycled as a source of nitrogen for crops thereby limiting the use of industrial fertilizers (Fig. 1).

$$H_3P0_4\,(aq) + 2\,NH_3\,(g) \rightarrow (NH_4)_2HPO_4 \qquad (1)$$

BABS™ (BioABSorber) produced by Sorba Absorber GmbH, is the spongy body obtained after removing the bark of maize stalks

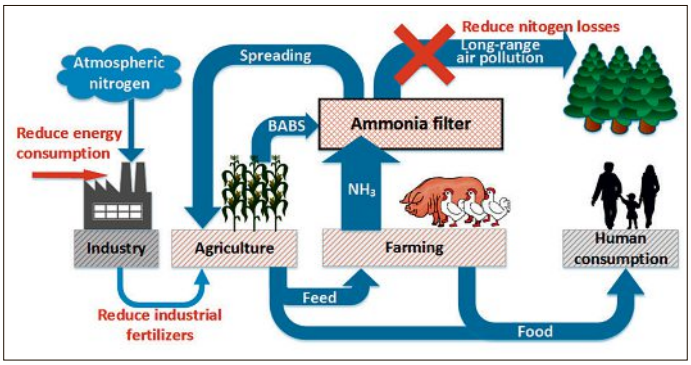

Fig. 1. Preservation of the nitrogen cycle by trapping ammonia emissions from poultry and swine facilities. Used filters can be used as fertilizer.

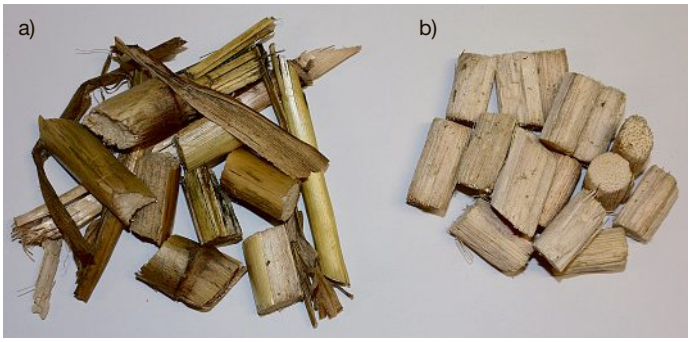

Fig. 2. Raw corn stover (a) and BABS™ after removing lives and bark (b).

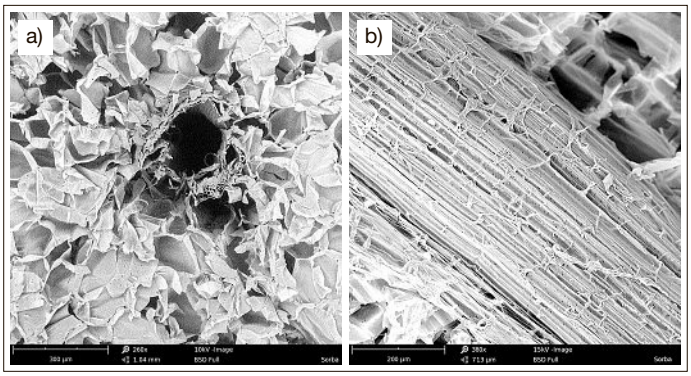

Fig. 3. Cross section (a) and longitudinal section (b) of BABS by scanning electron microscope (SEM).

(Fig. 2). It is a biosourced and biodegradable material which has a capacity of water retention up to 40 times its weight. Maize stalks are composed of large vascular bundle surrounded by a ground tissue with a large specific surface area (Fig. 3).

Ammonia Abatement in Poultry Facilities

BABS™ is impregnated with a solution of phosphoric acid and is used as a filter on the output of an air extractor of a livestock facility. Ammonia concentration before and after filter was measured simultaneously using two calibrated chemical sensor, model Libelium Smart Environment PRO waspmote Plug&Sense with temperature, humidity, pressure sensors and calibrated ammonia sensor (ref 9378-P, range 100ppm, accuracy ±0.5ppm). The filter is designed for a residence time of 0.5 second. The prototype was first tested under laboratory conditions with synthetic air of about 25 ppm of ammonia obtained by dilution of a reference gas (Carbagas BLUE 1% ammonia in air). The ammonia concentration after the filter is often below the limit of detection of 1ppm. Under these conditions, the relative ammonia absorption is >95%.

A prototype of 400 L of BABS was subsequently tested in a poultry facility during a 36-day growth cycle. Due to the low concentration of ammonia in the broiler housing, from 2 ppm to 5.5 ppm after 5 weeks, the tests were carried out only during the last two weeks. During this time a fan extractor of 1000m^3/h capacity pulsed untreated gas through the filter. The filter humidity is maintained through a timed-interval sprinkling with water. As in the laboratory tests, the concentration of ammonia at the filter output remains below 1ppm. It should be noted that after two weeks of use the amount of dust on the filter causes a significant pressure drop. There is also a partial drying of the filter media. A future study should be considered to optimize the sprinkling and add a preliminary dust filter.

Conclusion

A new exhaust air cleaning system for reducing emissions of ammonia from poultry growing unit has been developed and tested. The system consists of maize straw impregnated with phosphoric acid. The prototype tested in real condition of poultry facility showed an abatement of >95% of ammonia emissions. This strategy of ammonia emission reduction offers an economically acceptable solution for agriculture. It can be apply for poultry and swine farms and on manure storage facilities. As the substrate is fully biodegradable, spreading of used filter on crops can reduce fertilizer consumption and limit losses in the nitrogen cycle.

[1] B. Reidy, B. Rhim, H. Menzi, *Atmos. Environ.* **2008**, *42*, 3266.
[2] L. Gong, R. Lewicki, R. Griffin, *Atmos. Environ.* **2013**, *77*, 893.
[3] T. Kupper, C. Bonjour, H. Menzi, *Atmos. Environ.* **2015**, *103*, 215.
[4] 'Nitrogen-containing air pollutants affect biodiversity', *http://www.bafu.admin.ch/luft/00575/11210*, Federal Office for the Environment, **2016**, accessed June 2016.
[5] W. Gramatte, J. Johann, 'DLG Test Report 5952, MagixX-B exhaust air cleaning system', Deutsche Landwirtschafts-Gesellschaft, **2009.**

Production of Poly(3-hydroxyalkanoates) Biopolymers from Syngas Using *Rhodospirillum rubrum*: Turning Waste into Treasure

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Poly(3-hydroxyalkanoates) (PHA) are bio-based and biodegradable alternatives to conventional polymers derived from fossil fuels. In this work we assessed a novel type of production process that relies on fermentations using syngas (CO, CO_2, H_2 and N_2) as main substrate and *Rhodospirillum rubrum* as CO-metabolizing and PHA-producing strain. Syngas can be obtained from the pyrolysis of organic wastes and thus represents an inexpensive, non-food-competitive carbon source. A cutting-edge process analytical technology platform including measurements of dissolved oxygen and redox potential, gas concentrations by mass spectrometry, as well as cell concentration and PHA content by flow cytometry was set up to monitor the bioprocess and cell physiology.

Preliminary experiments revealed the difficulty of culturing