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Detox NH_3 Textiles - Clean Air for Pig, Man & Environment

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Abstract The DTNW has been working successfully for many years on the development of so-called adsorber textiles, which are suitable, for example, for the enrichment and recovery of precious metals from industrial process waters, where they can make a significant contribution to improving circulation flows and sustainability. Our latest investigations focus the use of the functional textiles in the adsorption from gaseous phase - namely the adsorption of ammonia. Ammonia has a negative impact on the environment and health. The most important pollution emitter is the farming industry, where ammonia is produced during animal husbandry by excretions from pigs, cattle and chickens, for example. Bound in liquid manure, it is then mostly spread on arable land, where it contributes significantly to overfertilization and contamination of groundwater. In addition, gaseous ammonia is the basis for the formation of long-lived particulate matter, which can lead to severe respiratory diseases and it plays an important role in global warming because it can be transformed to climate-damaging nitrous oxide. Here, we present our results on the direct adsorption of ammonia in pigsties. In our pilot plant, the gas can be removed from the ambient air of the pig house in continuous operation and at the same time converted into a valuable mineral fertilizer that is easy to transport and therefore no longer needs to be applied directly at the point of origin.

Keywords: textile, polyelectrolyte, ammonia, farming industry, fertilizer

1. Introduction

The recycling and recovery of high-prized noble metals such as platinum, gold, palladium and silver or rare and strategic metals like indium, gallium, and rare earth metals from scrap metals and wastewaters will be from steadily increasing importance within the next years. Therefore, the focus has to be set on the detection of potentially usable secondary resources and the development of inexpensive and energy-saving processes to separate and recover the metals selectively (urban mining) [Xavier et al., 2023]. Beside electronic scrap industrial process and wastewaters represent a considerable source for noble metals. Some years ago, we have successfully developed an innovative metal-adsorbing textile filter material based on various polyelectrolytes. The surface modification of the fibrous material is easy to realize with common methods in textile finishing yielding a durable, high-performing and even cheap fiber-fixed polymer network. The feasibility of the overall process was demonstrated successfully on various palladium containing process waters obtained from producers of curcuit boards and metal plating industry [Opwis et al., 2015].

Moreover, these innovative textile adsorber materials are useful, e.g., for the decontamination of chromate-polluted ground waters as well as waters polluted with perfluorinated alkylated substances (PFAS) [Mayer-Gall et al., 2015].

Our latest investigations focus the use of the functional textiles in the adsorption from gaseous phase - namely the adsorption of ammonia. Ammonia has a negative impact on the environment and health. It causes particulate matter pollution and plays an important role in global warming because it can be transformed to climate-damaging nitrous oxide. The most important pollution emitter is the farming industry [Wyer et al., 2022].

2. Methods

Polyacrylic acid (PAA) and suitable cross-linking agents were used for textile finishing on both laboratory and industrial scale. The materials were thermally fixed at 150 °C. The textile was then washed and dried. The successful immobilization of PAA was verified by various analytical methods such as gravimetry, UV-Vis spectroscopy and colour reactions. The amount of ammonia adsorbed was determined using Kjeldahl.

3. Results

3.1. Textile Functionalization

The textile finishing is based on the permanent fixation of the negatively charged polyelectrolyte PAA. The main parameters of the process, such as concentration, temperature, time, etc., were first optimized in the laboratory during the course of the project and then scaled up. Figure 1 (left) shows the production of the adsorber textile on an industrial scale.

3.2. Ammonia Adsorption

Ammonia adsorption was tested with various prototypes of different dimensions both in pigsties (Figure 1, right) and in production facilities in the printed circuit board industry. Depending on the scenario, between 15 % and 100 % of the ammonia present can be removed from the ambient air. Figure 2 shows an example of the reduction of ammonia pollution in the test area of PCB production. A valuable mineral fertilizer can be obtained by continuously regenerating the adsorber textile with phosphoric acid.

4. Summary

Our textile research institute (Deutsches Textilforschungszentrum Nord-West, DTNW) has been working successfully for many years on the development of so-called adsorber textiles, which are suitable, for example, for the enrichment and recovery of precious metals from industrial process waters, where they can make a significant contribution to improving circulation flows and sustainability. In an R&D project funded by the state of North Rhine-Westphalia and the EU, representatives from industry, agriculture and research have come together to expand the potential of such adsorber textiles. In addition to the research institution DTNW, which provided the ideas, these include the textile manufacturer Kayser Filtertech, the Gesellschaft für Innenraumhygiene mbH, the printed circuit board manufacturer Unimicron Germany GmbH, and the Schulze Esking pig fattening operation in the Münsterland region, which is strongly influenced by agriculture. The specific case involved the removal of ammonia gas, which is produced during animal husbandry by excretions from pigs, cattle and chickens, for example. Bound in liquid manure, it is then mostly spread on arable land, where it contributes significantly to overfertilization and contamination of groundwater. In addition, ammonia is the basis for the formation of long-lived particulate matter, which can lead to severe respiratory diseases and, last but not least, the toxic gas affects the health of humans and animals directly in the livestock farms. In the course of the project, it has now been possible, on the one hand, to manufacture and equip the adsorber textile on an industrial scale. On the other hand, a pilot plant was successfully tested under real conditions in pig fattening. In this process, the gas can be removed from the ambient air of the pig house in continuous operation and at the same time converted into a valuable mineral fertilizer that is easy to transport and therefore no longer needs to be applied directly at the point of origin.

Figure 1. Production of the adsorber textile on industrial scale (left) and first prototype for the removal of ammonia in pigsties (right).

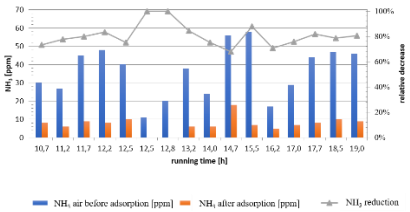

Figure 2. Reduction of ammonia pollution in production areas of the printed circuit board industry through the use of functional adsorbent textile.

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