COLORIMETRIC HCL AND NH3 SENSING VIA DYE MODIFIED SILICON OXIDE NANOFIBROUS MEMBRANES

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Abstract

Fast, accurate and reversible colorimetric sensors for acidic environments both in water and air are highly valuable for various applications, such as safety and technical textiles. The detection of NH_3 and HCl gases using optical sensors in industrial processes is of great interest due to the simplicity and sensitivity of these sensors. Until now sol-gel based colorimetric sensors are usually non-flexible bulk glass or thin film sensors [1]. By combining sol-gel and textiles sensor materials can be produced with highly promising characteristics, namely flexibility, reusability, breathability and mechanical stability [2]. These halochromic membranes can cover a large area but still result in a local signal. The use of a ceramic matrix gives the opportunity to use these sensors in harsh environments where polymers are no longer usable. In this study, large area flexible silicon oxide nanofibrous sensors are developed which allow fast and accurate detection of HCl (both in water and air) and NH_3 vapors without the need of additional electronic devices.

By combining sol-gel and electrospinning organically modified silicon oxide nanofibers were prepared. Usually organic polymers are added to the alkoxide precursors to enable electrospinning, after which the polymer components are removed via a thermal treatment. In this study, electrospinning was carried out without addition of an organic polymer to the precursor solution. This is the preferred method to produce silicon oxide nanofibrous membranes for sensing applications. It makes the high temperature thermal treatment unnecessary, which would be deleterious not only for the nanofibrous structure but also for the introduced sensing functionality.

A halochromic dye was incorporated in these nanofibers via two methods, namely doping and covalent bonding. Large, uniform, flexible, deeply colored membranes were obtained for both types of sols. To sense pH changes in water and to prevent dye leaching the covalent bond showed to be essential. These nanofibrous sensors showed a fast response time, high sensitivity and reusability as pH sensor in aqueous environment. In addition, a high sensitivity for the sensing of HCl and NH_3 vapors was obtained with both types of membranes. Moreover, a memory function was seen allowing a read-out up to 20 minutes after exposure to the vapors. Due to their immediate and clear color change upon exposure to hydrogen chloride or ammonia vapors, these nanofibrous membranes showed to be ideal to be used as a visual warning patch in personal protective clothes or equipment.

References

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