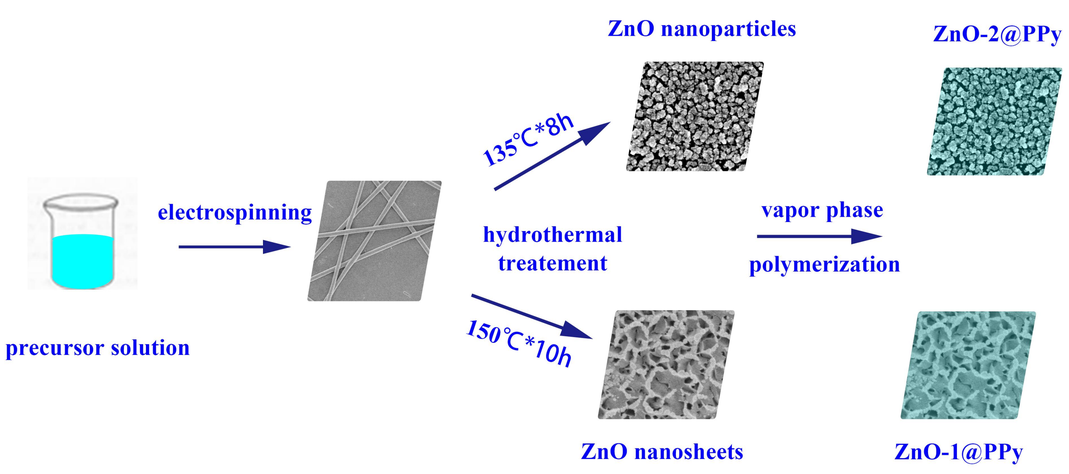
Green preparation of nanostructured ZnO and gas sensing properties of its hybrids with polypyrrole

Mingfei Jiao（21429010), Yang Li*, Mujie Yang

MOE Key Laboratory of Macromolecular Synthesis and Functionalization, Department of Polymer Science and Engineering, Zhejiang University, Hangzhou China

Introduction

Rapidly increasing environmental pollution has been recognized as a major concern, and its monitoring has become a priority area for human health. This fact has led efforts to find new and user-friendly techniques for the detection of gases hazardous to the environment and human health. Gas sensors have become one of the key technologies for rapid, selective, sensitive, and efficient detection of gases, chemical vapors , and explosives. Recently, organic-inorganic hybrid nanocomposites have been focus of attention for their synergetic/complementary effects. In this paper, we demonstrated a green approach to get nanoscaled ZnO-Polypyrrole hybrid composites via electrospinning and hydrothermal method. The nanohybrid showed wide sensing range (0.5-200 ppm), very high response magnitude (20% towards 0.5 ppm of NH_3), good repeatability and desirable selectivity.



Results and discussion

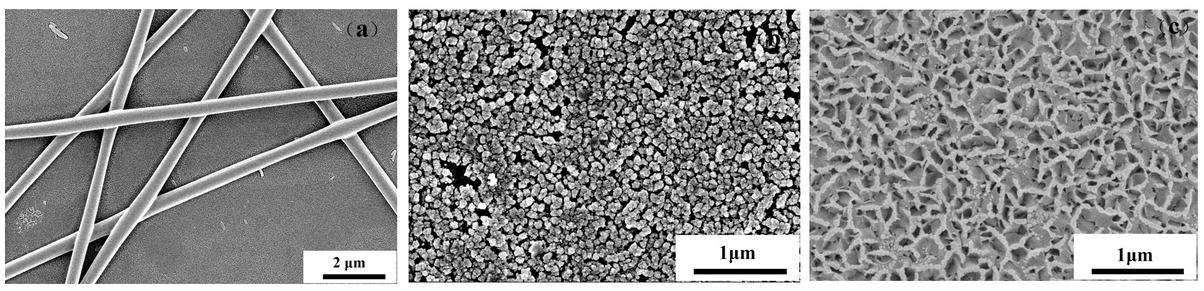


Fig. 1 SEM micrographs of electrospun nanofibers (a) before and (c-f) after hydrothermal treatment for different conditions: (b): T = 135°C, t = 8 h; (c): T = 150°C, t = 10 h.

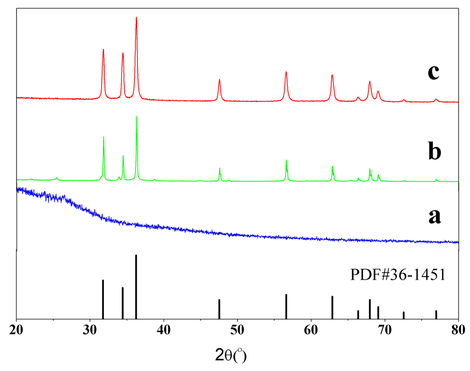


Fig. 2 XRD patterns of (a) PPy; (b) as-prepared nanostructured ZnO and (c) nanohybrid of ZnO with PPy.

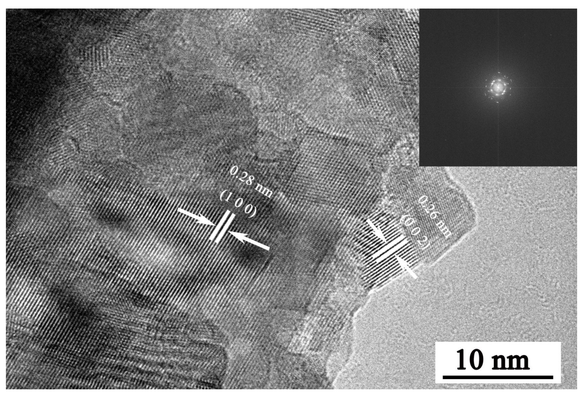
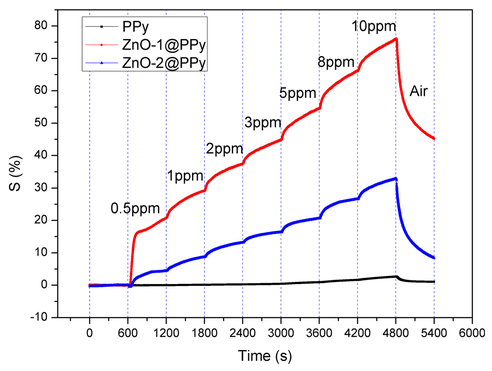


Fig. 3 HRTEM image of as-prepared nanostructured ZnO.



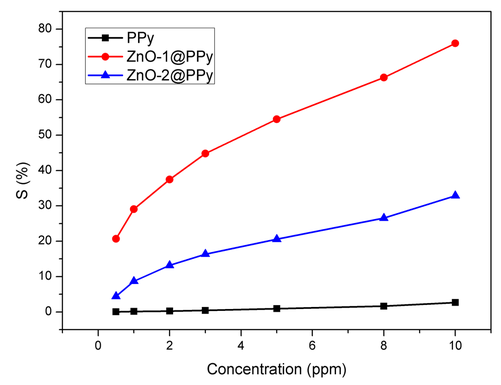


Fig. 4 Calibration curves and dynamic responses to NH_3 of different concentrations of (a) PPy; (b) ZnO-1@PPy and (c) ZnO-2@PPy at room temperature.

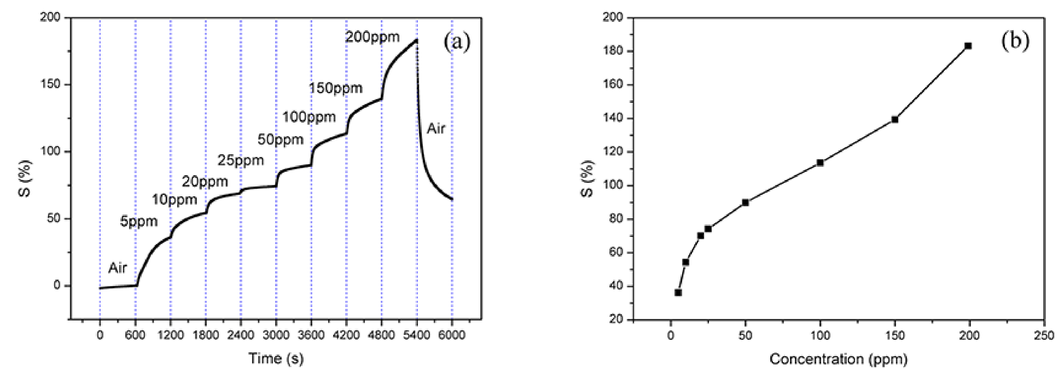


Fig. 5 Dynamic responses (a) and Calibration curve (b) of ZnO-1@PPy towards NH_3 over a wide range of concentration at room temperature.

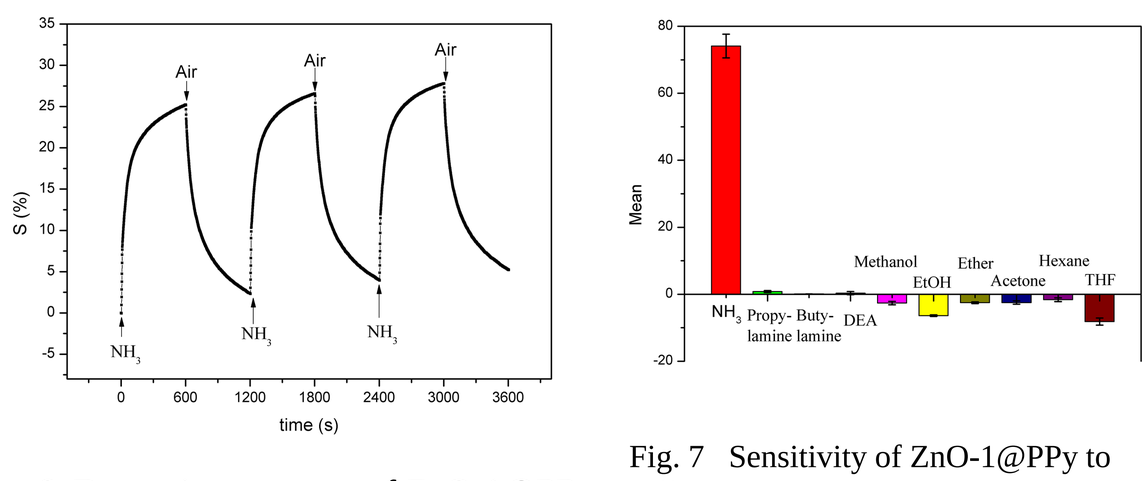
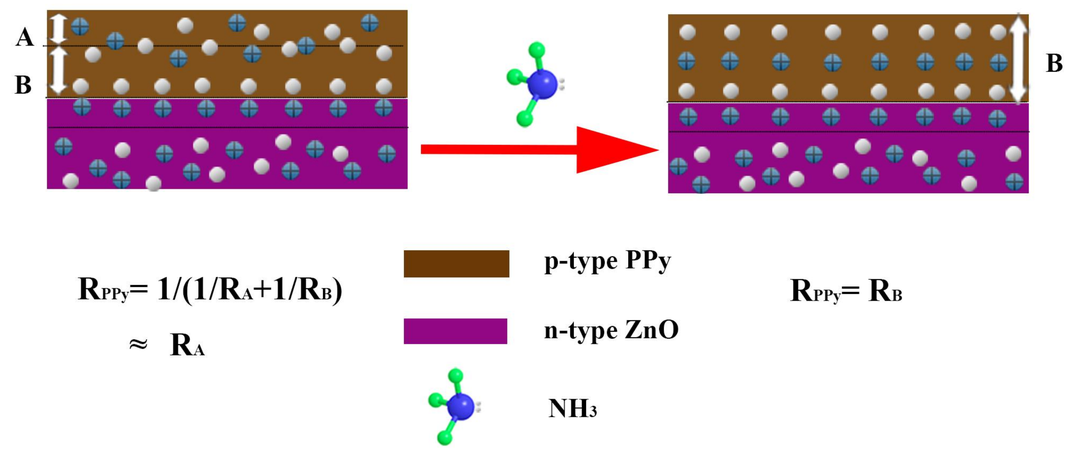


Fig. 6 Dynamic responses of ZnO-1@PPy at room temperature during alternate exposure to air and 5 ppm of NH_3.

Fig. 7 Sensitivity of ZnO-1@PPy to different vapors at room temperature. Concentration of the vapors: [NH_3] = 10 ppm; [PA] = [BA] = [DEA] = 10 ppm; 5000 ppm for other organic solvents.



Scheme 1 Illustration of interactions of ZnO/PPy nanohybrids with NH_3.

Conclusions

Nanostructured ZnO could be in-situ grown on the substrate via combination of electrospinning with hydrothermal treatment. The synthesis is carried out in water solution and avoids high temperature calcination, representing a green approach. The nanohybrid of ZnO with vapor phase polymerized polypyrrole displayed high sensitivity (~ 20% towards 0.5 ppm of NH_3), wide sensing range, repeatable and highly selective response to NH_3 at room temperature. The p/n junction between p-type PPy and n-type ZnO plays a major role in the superior sensory properties of the nanohybrid.

This work was financially supported by the National Natural Science Foundation of China (Contract no. 51273174 and 51073134).