INSTITUTE BioSense

UNIVERSITY OF NOVI SAD FACULTY OF TECHNOLOGY NOVI SAD

ECerS 2017
15th Conference & Exhibition of the European Ceramic Society
July 9-13, 2017 / Budapest, Hungary

THE INFLUENCE OF THE DISPERSANTS ON PRINTING INK PROPERTIES OF METAL OXIDES NANOPARTICLES

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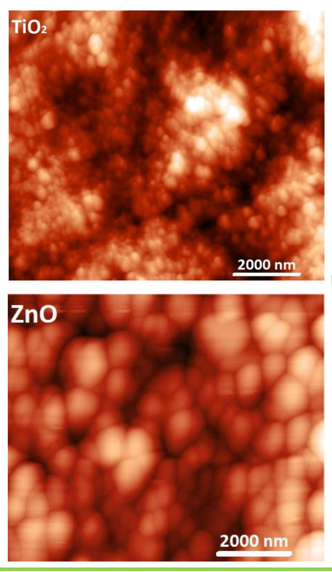
Abstract

In this work, stable homogeneous suspensions of MOx (TiO_2 and ZnO) were prepared using gum arabic (GA) and Solsperse 40000 as dispersants. GA is a natural polyanionic polysaccharide with carboxylic groups as anchors, while Solsperse 40000 is an anionic phosphated alkoxylated polymer of Lubrizol. Both dispersants provide electrosteric stabilization of pigments in water based inks. GA was employed as dispersant to study the effect on the surface properties of MOx nanoparticles. GA has been used as the stabilizing agent for ink pigments for a long time. It is well known that GA can make the MOx nanoparticles have a good dispersibility and stability in GA colloidal solution for its low viscosity. The investigations on the optimum concentration of dispersants and the mechanism determining the dispersion behavior of MOx in aqueous dispersants solution were performed. Suspensions of MOx and GA/Solsperse were prepared first by dissolving dispersants in water. MOx were added in appropriate amounts. The weight ratio between MOx and GA (solsperse) was varied from 1/1 to 3.5/1. The ball milling was performed in a Retch PM 100 planetary ball mill at constant milling speed of 250 rpm using YSZ jar and balls. The effects of different milling time (15, 30, 60, 90 and 180 min) on average particle sizes were investigated. Results show improved dispersion with reduction of average particle sizes with increasing of milling time. Different ink formulations composed of MOx/dispersants (with addition of 1, 2 propylene glycol and n-propanol) were prepared and their printability properties were tested using Ink-jet printer Fuji Dimatix DMP-3000.

Experimental



AFM images of TiO_2 and ZnO powders

Mill base formulation
- aqueous solution of dispersant
- MOx
- IKA T-25 Ultra-turrax; 10 min, 15 000 rpm

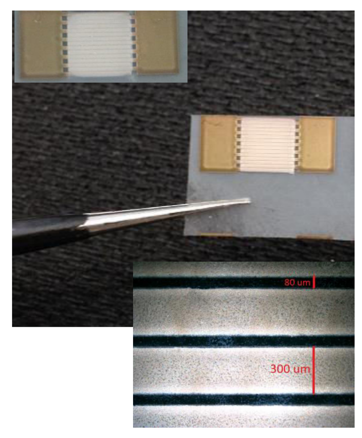
Milling
- **Retsch Planetary Ball Mill PM100;** 250 rpm
- YSZ jar (50 ml) and balls (2 mm diameter)

Ink formulation
- Mill base
- Distilled water
- Propylene glycol
- n-propanol
- IKA T-25 Ultra-turrax; 5 min, 15 000 rpm
- Filtration: Whatman 1.0µm GF/B

Particle size measurements
- Malvern Zetasizer Nano ZS

Inkjet printing
- **Fuji Dimatix DMP-3000 inkjet printer**
- Jetting voltage, frequency and waveform → stable droplets
- PET substrate

Thermal treatment:
IDE (Ag) – 1h @ 200°C
Printed film – 2h @ 100°C



Printed sensor

Fig. 1. From nanoparticles to sensors

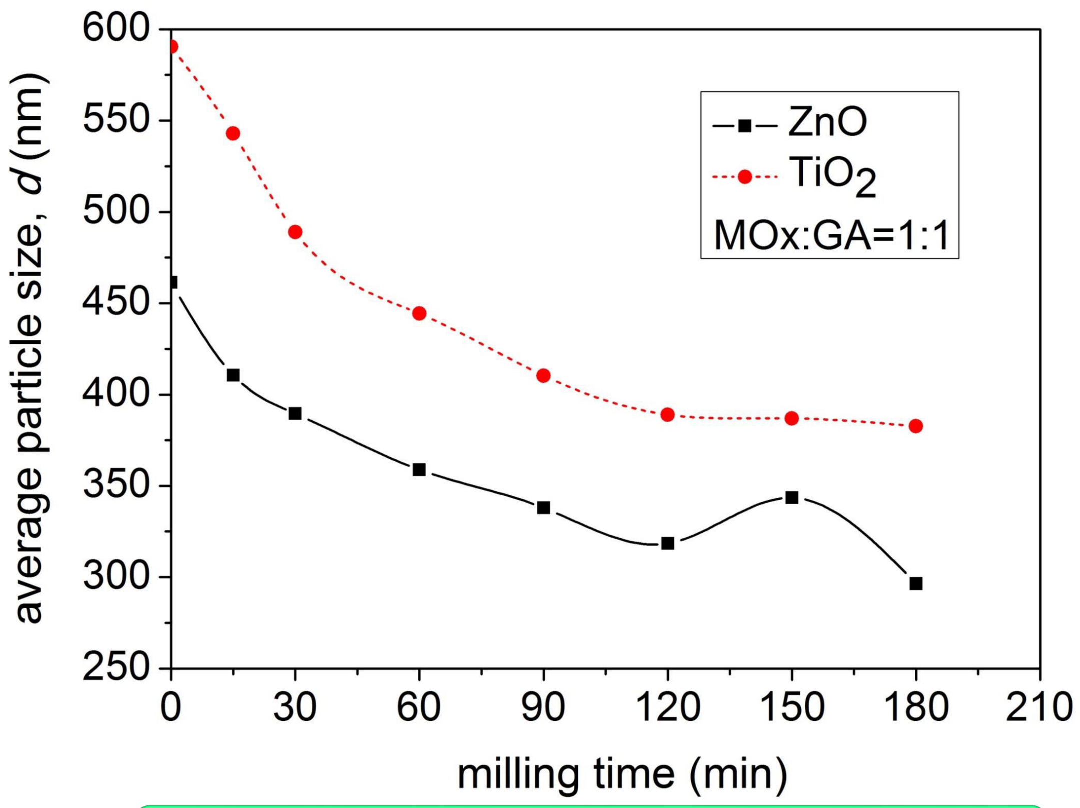


Fig. 2. Average particle size vs. milling time

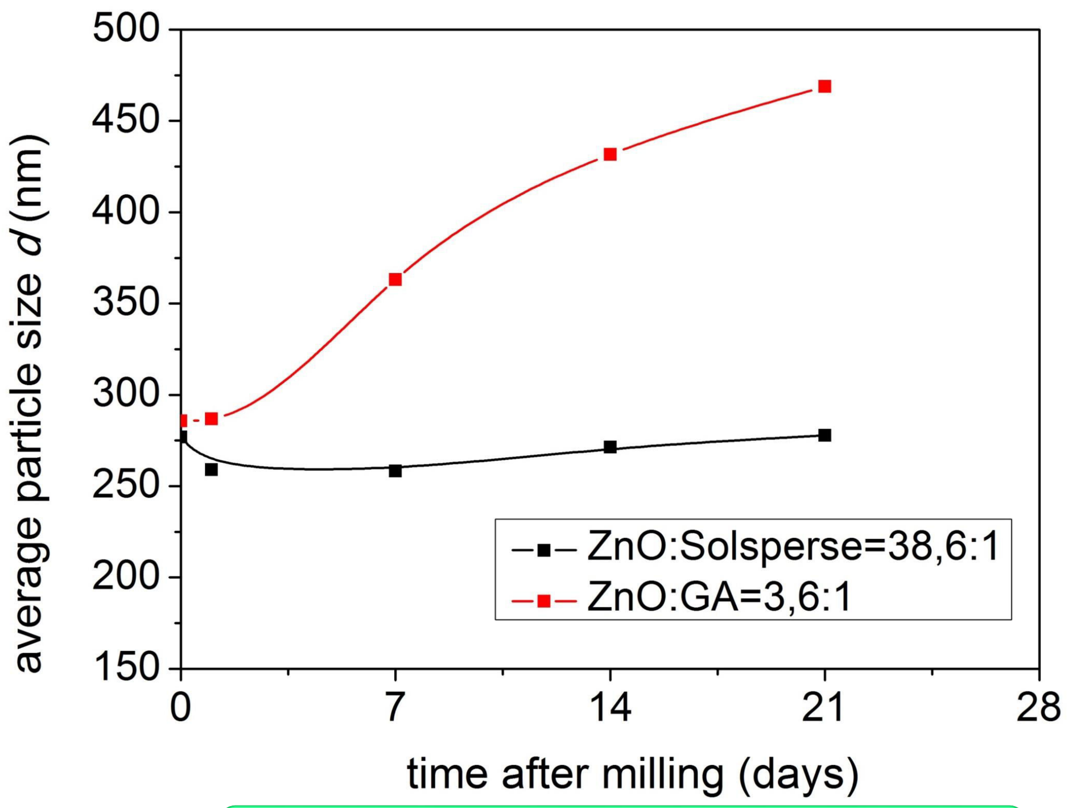


Fig. 3. ZnO inks aging

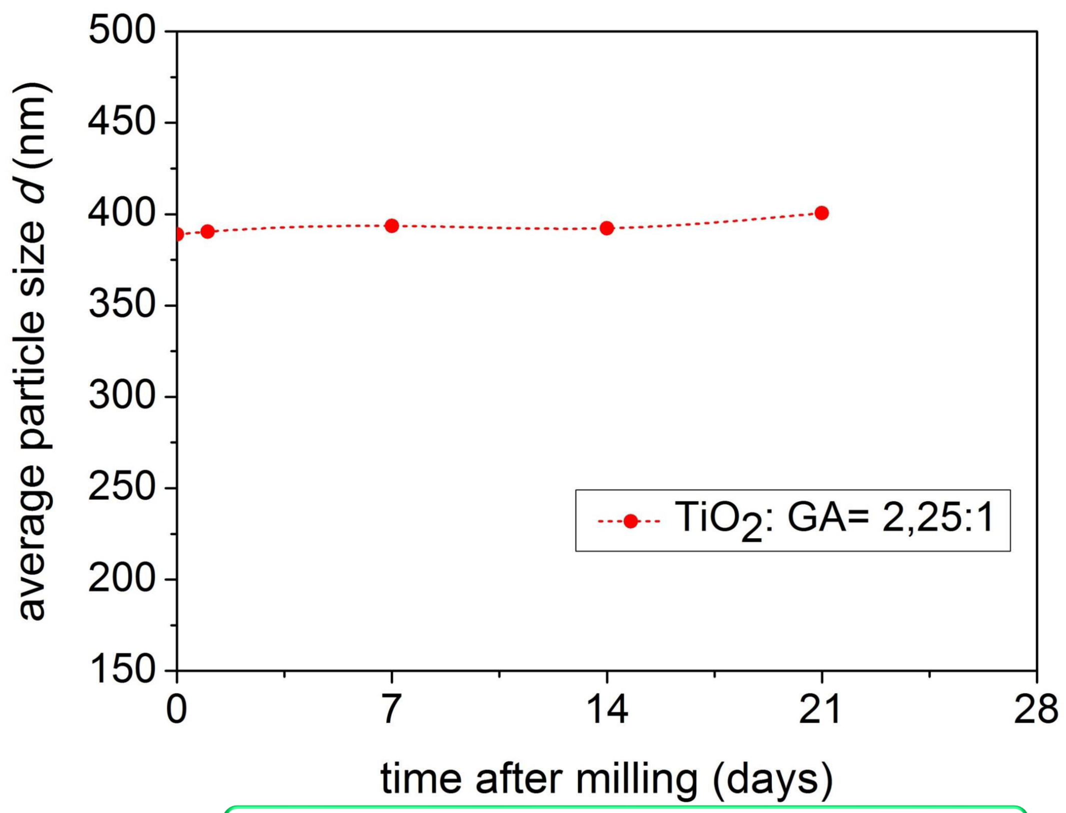


Fig. 4. TiO_2 ink aging

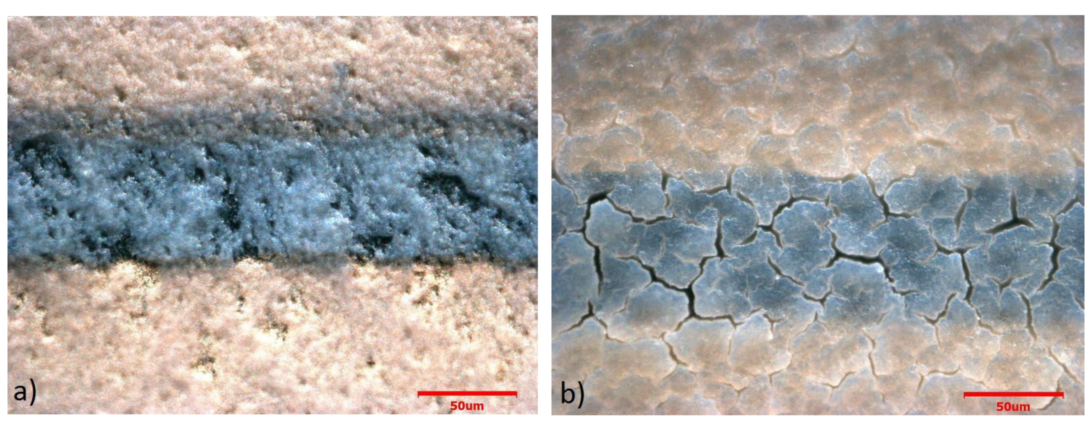


Fig. 5. Optical microscope images of: ZnO:Solsperse (a) and TiO_2:GA (b)

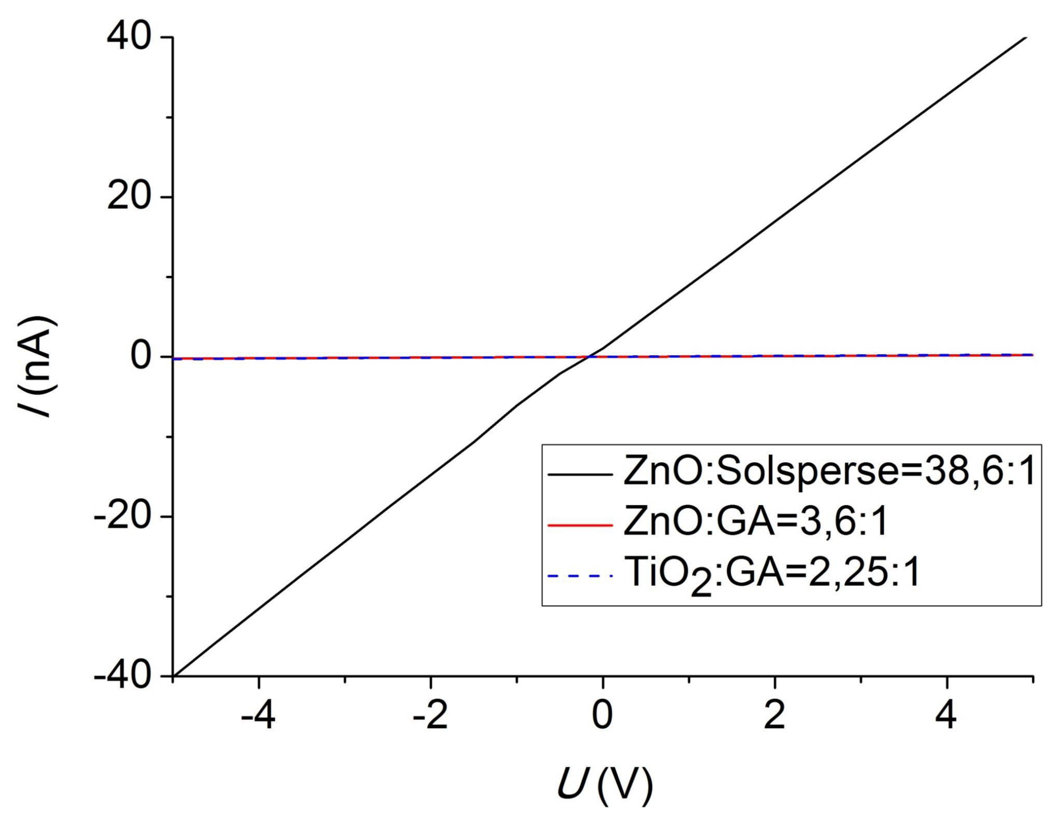


Fig. 6. *I-U* curves of ZnO and TiO_2 inks

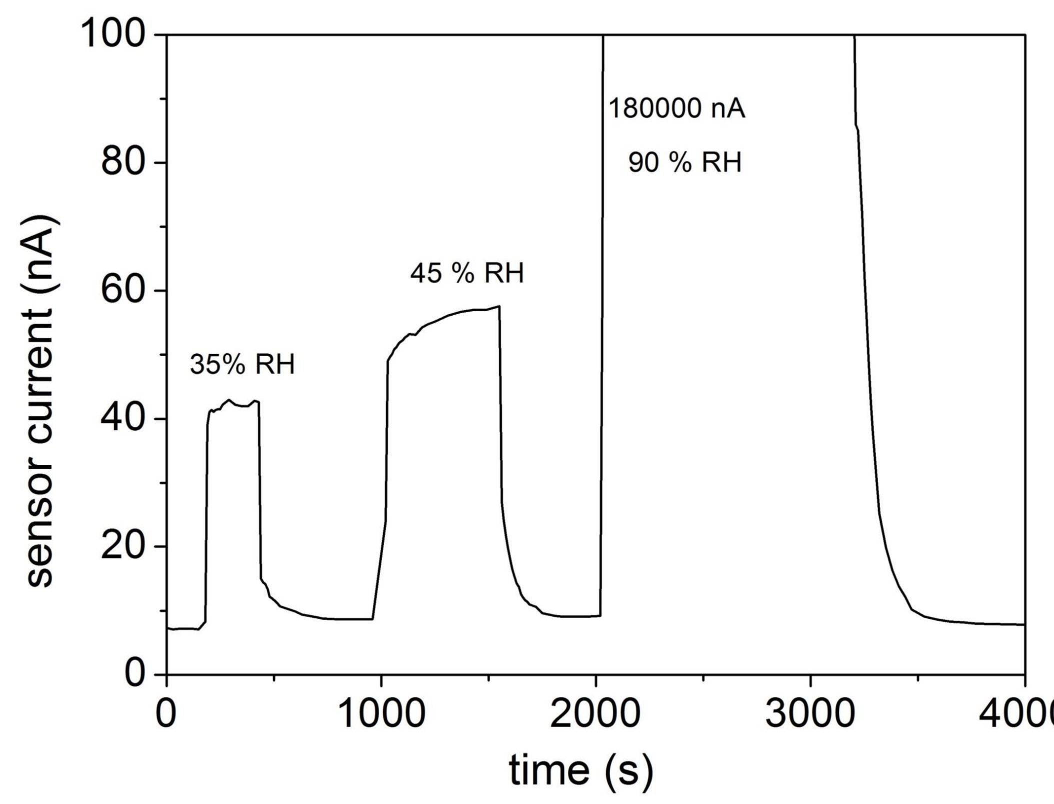


Fig. 7. Humidity response of ZnO:Solsperse based sensor

Conclusion

- 90 min was obtained as optimal milling time.
- Mechanical milling up to 90 min resulted in significant reduction of the average particle size: from 600 nm to 420 nm in the case of TiO_2, and from 460 to 330 nm in the case of ZnO, while some negligible change was observed upon prolonged milling of both suspensions.
- ZnO:Solsperse and TiO_2:GA inks showed good stability during aging experiment within 3 weeks.
- Electrical characterization revealed that ZnO:Solsperse ink gave higher sensor current in comparison with ZnO:GA ink.
- ZnO:Solsperse based sensor showed very fast response time and high sensitivity to 90% RH.