Zinc oxide nanowires for drug delivery systems

Atif Syed[a], Vasileios Koutsos, Enrico Mastropaolo[b]
School of Engineering, The University of Edinburgh, UK
[a]*a.syed@ed.ac.uk ;* [b]*e.mastropaolo@ed.ac.uk*

Dimitrios A. Lamprou,
Medway School of Pharmacy, University of Kent, Canterbury, UK

Monika Warzecha, Philipp F. Seib
Strathclyde Institute of Pharmacy and Biomedical Sciences,University of Strathclyde, Glasgow, UK.

Design and fabrication of nanoscale drug delivery systems have attracted a lot of attention for the past few years. The need for high drug loading and cost-effective and controlled release has pushed researchers to design and fabricate novel nanoscale drug delivery systems. Zinc oxide (ZnO) nanostructures have attracted a lot of interest due to inherent biocompatibility[1] and low toxicity[2]. In particular, ZnO nanowires (NWs) were used to successfully deliver an anticancer drug (daunorubicin) by using photodynamic therapy[3]. Using ZnO NWs for drug delivery is a fairly new area of research which requires further understanding of the release mechanisms, surface chemistry and toxicity.

In this work, we present the hydrothermal synthesis of ZnO NWs together with Nile red (Nr), a lipophilic/hydrophobic fluorescent molecule. In our experiments, Nr acts as a hydrophobic model compound which is used to mimic drug loading and drug release. The experiments have been carried out using four different ZnO NWs/Nr formulations so that the influence of synthesis temperature and NWs size on Nr loading/release.
Fig. 1 shows a scanning electron micrograph of the ZnO NWs/Nr. Fourier transform infrared spectroscopy (FTIR) (Fig. 2) revealed strong anchoring between ZnO NWs and Nr thus indicating a robust interaction between them. Furthermore, atomic force microscopy (AFM) and SEM have allowed observing the morphological changes on the surface of the NWs due to the Nr loading. Water contact angle measurements performed onto the NWs/Nr showed a substantial increase due to the hydrophobicity of organic dye used. From the measurements, we have observed that specific synthesis temperatures and NWs sizes enhance the drug loading/release (Fig. 3). Finally, in vitro tests have been carried out for investigating toxicity towards macrophage-like cells.

The work done shows that ZnO NWs are excellent candidates for nanoscale delivery of hydrophobic drugs. In this paper, we will present and discuss the details of the aforementioned results and provide the specific conditions to support maximum drug loading and drug release. In addition, the paper will include an in-depth analysis correlating crystallite sizes (by using x-ray diffractometer) with drug loading/release properties of the ZnO NWs.

---

[1] Z. Li, *et al*., J. Phys. Chem, **112**, 20114, 2008
[2] K. H. Muller, *et al*., ACS Nano, **4**, 6767, 2010
[3] H. Zhang, *et al*., Biomaterials, **32**, 1906, 2011

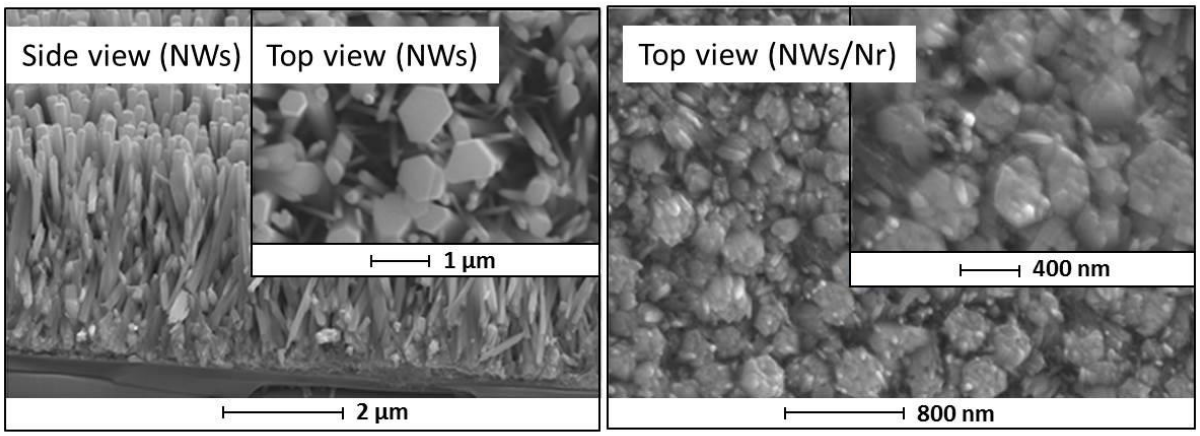

Figure 1: Scanning electron micrographs of pure zinc oxide nanowires (ZnO NWs) and zinc oxide nanowires synthesized with Nile red (ZnO NWs/Nr).

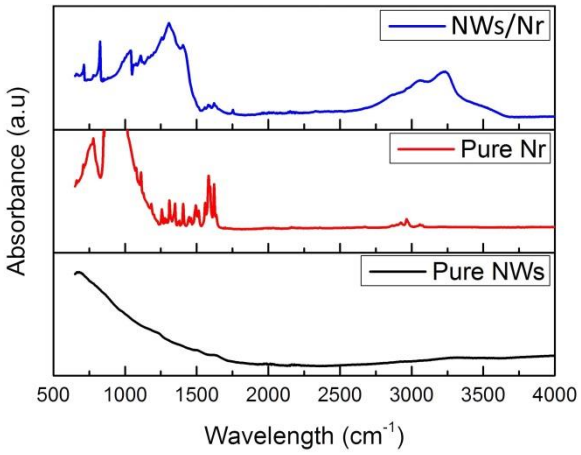

Figure 2: FTIR spectra of pure zinc oxide nanowires (ZnO NWs), pure Nile red (Nr) and nanowires synthesized with Nile red (NWs/Nr.

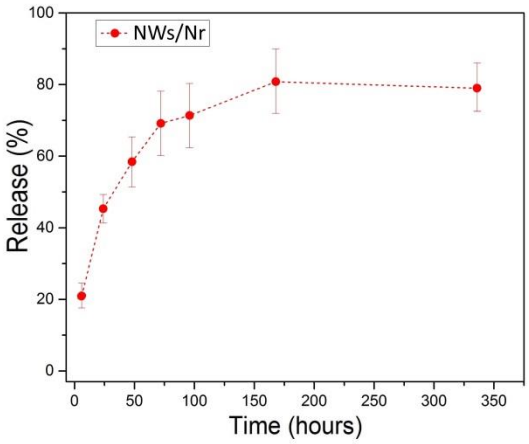

Figure 3: Release curves of the nanowires synthesized with Nile red (NWs/Nr) over 2 weeks.