Tapas Sen Edited Interview

Dr Tapas Sen speaks with Dan Sharpe, Commissioning Editor of *Nanomedicine*.

Dr Tapas Sen is a Reader in Nanomaterials Chemistry at the University of Central Lancashire (UCLan). He trained as a chemist, achieving his BSc. Hons in Chemistry, MSc in Physical Chemistry, and PhD in Materials Chemistry from the National Chemical Laboratory, Pune, India. Alongside his academic posting, he is an editorial board member for several journals including *Nanomedicine*.

His work at UCLan is multidisciplinary, drawing from chemistry, material science, biology, and medicine to work with industry and academic partners to address challenges in health and environmental sciences. The research group currently has three projects: (1) magneto-optical nanocomposites for liver cancer therapeutics; (2) the separation and identification of viral RNAs using magnetic nanoparticles in the context of coronavirus; and (3) developing multifunctional nanocomposites for the detection and separation of wastewater toxicity and treatment.

Could you share a turning point or defining moment in your work as a scientist?

As scientists, we can only work on a challenging problem if we have the right group of people and the funding. My background is a chemist, but I realized in 2004 that focusing only on chemistry could be challenging in terms of financial support for my research. At that point, I decided to move into the interface of chemistry, biology, and medicine. I was very fortunate to work on two important projects under the FP5 and FP6 European programs during my time in the University of Greenwich and Universit of Kent, and both were on health science and medicine. In the first, I worked with Royal Phillips Netherlands under FP6 programme (NACBO) to develop magnetic nanoparticles for MRI contrast agents which has been used in their commercially available MRI machine. This decision to become a chemist developing magnetic nanoparticles for MRI was one of the breakthroughs in my career in order to enter in the area of Nanomedicine research.

My involvement in second project under the FP6 programme (CHILLON) focused on detecting foodborne microorganisms in frozen food samples as biologists struggled to find them in a limited timeframe as the classical route of cell culture can take days to grow in a laboratory condition. In collaboration with Q-Bioanalytic in Germany, we developed controlled and tunable nanoparticles with magnetic property which we call superparamagnetic iron oxide nanoparticles (SPIONs). They could separate nucleic acid from frozen food samples using one-step protocol and that has eliminated two existing protocols the industry used at that time. This novel magnetic nanoparticles (SPIONs) has been commercialized in the context of nucleic acid separation kit for biologists.

I thought I should share these two important achievements as my research turning points because those two areas have been funded externally in the past and presently. Therefore, they are my main research focus for the next 10 years.

Could you outline the outcomes from your recently completed work on multifunctional nanoparticles in cancer therapy funded by a grant from the UK India Education and Research initiative (**UKIERI)?**

This project began in 2017 and completed last year with the success of a PhD student completed her thesis inSeptember 2022. The aim was to develop multifunctional nanocomposites in cancer therapy from my earlier research under the FP5 & FP6 programmes. We thought that introducing another dimension – optical sensitivity – to create magneto-optical nanocomposites useful for multimodal

treatment and diagnosis. The advantage of magnetic center is that the nanoparticles can be directed towards the cancer using an external magnetic field, and can be visualised by applying them asMRI contrast agent as a diagnostic tool.

Due to its cost, MRI might not be available in every institute, so the optical sensitivity enables fluorescence imaging of the particles using a suitable optical photosensitizer combined with magnetic core. This means that one can visualize these magneto-optical nanoparticles loaded with drug molecules to the tumor site either by MRI or fluorescence imaging techniques before applying therapy. There are locaslied treatment options using the magneto-optical nanoparticles. First, one can apply an alternating magnetic field (AMF) using a specialised equipment to create localized heat from the magnetic centres which we call ablation therapy. Second, the optical component means that by shinning laser light of certain wavelength in the fluorescence or near infrared (NIR) regionlights, can create localized heat in a process called Photothermal therapy (PTT). We also checked the production of reactive oxygen species (ROS) which is essential for another method called photodynamic therapy (PDT) for cancer cell killing.

The importance of introducing the optical component into our well-developed magnetic nanocomposites is that the magneto-optical nanocomposites have multimodality for cancer therapy and diagnosis. If achieved, this can detect the early-stage cancer and eliminate the complex surgical operation especially for vulnerable patients.

What will your lab be working on next?

Our goal is to apply our research in a real-life situation to address rather than researching for research's sake. We have recently received a small grant from Royal Society of Chemistry, UK in collaboration with East Lancashire Teaching Hospital focused on addressing hepatocellular cancer (HCC). Cancer Research UK states that this is the eighth most common cause of cancer-related deaths in the UK and the third leading cause of cancer mortality worldwide. With most patients diagnosed at an advanced stage, survival rates at 5 years are very low. Our area in the northwest of UK is an epicentre for such condition. In this project we are applying our already developed magneto-optical nanoparticles as a part of our recently completed UKIERI project to treat liver cancer.

These magneto-optical nanoparticles have been tested for liver cancer cell lines in vitro, followed by in vivo using mouse model with very encouraging results. Those results, we want to transform to ex vivo, that means using human liver cancer tissues from the patients supplied by clinicians after surgical operation, and then eventually we want to test this technology for clinical trials. The project is directly in collaboration with two clinicians and a pathologist from the Royal Blackburn Teaching Hospital, Blackburn, UK.

We will also be working on Nano-water project involving toxic biochemicals from water for better environmental and separation of viral RNAs by using magnetic nanoparticles.

Finally, drawing on your research experience, where do you think the field of nanomedicine will be in 10 years' time?

The field of nanomedicine is growing, if you think about where it was when I started in 2004 and now in 2022. There is a lot of work being done to use materials in the nano dimension as a medicine. For example, in the current pandemic, nanoparticles which has been utilized in the Pfizer and BioNTech vaccine as RNA is encapsulated within lipid nanoparticles. The vaccine itself could be considered as new generation of nanomedicine.

In a separate dimension, cancer therapy, by using magnetic nanoparticles, the advantage is that applying the external magnetic field we can direct them to the cancer site. However, there are many issues come up as the toxicity of these inorganic nanocomposites are still a major issue. For another example, in bio-imaging, one of the classic nanomaterials that researchers have developed is quantum dots. These are optical nanocomposites which could have a very powerful imaging ability in the biomedical context, but they also have severe toxicity. We are in the process of developing non-toxic, biodegradable, biocompatible nanomedicines which could be utilized in the human body, some of which have been tested already in animal models.

Talking to clinicians, they believe that in 10 years' personalized medicines will be an important outcome in the field of nanomedicine. For example, if you develop a nanomedicine, you may think it could be used for everyone but there are people who have different sorts of complexity. In that context, we may need to develop personalized medicine, and nanomedicines developed with the proper understanding of the interface of chemistry and biology, can achieve that. This means not just a medicine which can be utilized in general, but that we can also treat an individual for their need as a personalized medicine using nanobiotechnology tools and methods.