OVERVIEW & ACTIVITIES IN FINANCIAL YEAR (2009/10):

General Given the scale of the nanotechnology industry and the importance of that NERC and end users attach to the environmental and human health hazards and risks of nanomaterials, the start up of FENAC's operation has proved to be of great interest to the relevant NERC research community and to a range of governmental and industrial, both globally and nationally. Of more surprise, is that there is considerable interest in FENAC from researchers investigating incidental and natural nanoparticles. FENAC has raised the profile of UK nanoscience research globally, for instance contributing to one of the two awarded US-UK consortium awards based on the NERC ENI round 2 (Lead is overall project lead on the other funded project, so will not use formally use FENAC), to an EU FP7 Infrastructure bid, and bids to the US NSF and Canadian NSERC. FENAC has also had discussions with organisations such as OECD and standards organisations (ISO, BSI). Nationally, FENAC is collaborating in the submission of 1 directed project (EEHI, funded jointly by NERC and MRC, with other partners), 3 standard grant proposals and 1 new investigator award. Details of the completed or current projects are given below. FENAC has also recently negotiated potential collaborations and links with the synchrotron facilities ISIS and DLS, with mutual benefits expected.

Method, Technology and Staff Development. The facilities available to FENAC at the programme start (April 2009) were substantial and are listed above in brief and the FENAC website in full. Further University of Birmingham funding has been leveraged to provide DLS, CE, BET, disc ultracentrifugation and FCS analysis (the latter with NERC support), with a value of ca £400 000. All instrumentation apart from the FCS has been installed and used routinely for analysis for FENAC projects. The FCS will be installed in July 2010 and will be available for projects from the May 2011 round. Further access to a university facility for analytical ultracentrifugation has been negotiated and is available to FENAC.

As part of the method development aspect of FENAC, a number of projects have been started with papers published, in press and in prep (details below). On-going projects involve i) extensive characterisation of size and other properties using a multi-method approach of commercial titania NPs in media containing high salt concentrations and organic bio-and geo-macromolecules and ii) the development of scanning near field optical microscopy on reference nanoparticles in the presence and absence of humic substances.

Of the 8 projects approved, 4 have involved PhD students being based at FENAC for short periods for training purposes. In addition, we have run 1 summer school attended by ca 30 doctoral and postdoctoral researchers (September 2009), with a second one planned for September 2010.

User surveys are routinely distributed and indicate high satisfaction with the FENAC facility but will be used critically to ensure this level is maintained.

Staffing arrangements

In the first 12 months of operation, two facility managers have accepted and resigned to accept positions elsewhere. This has put serious strain on the facility output and the first 5 months FENAC was without a manager to perform sample analysis. This has largely been overcome due to the excellence of the appointed staff and the help and support from other members of the Birmingham environmental nanoscience research team.

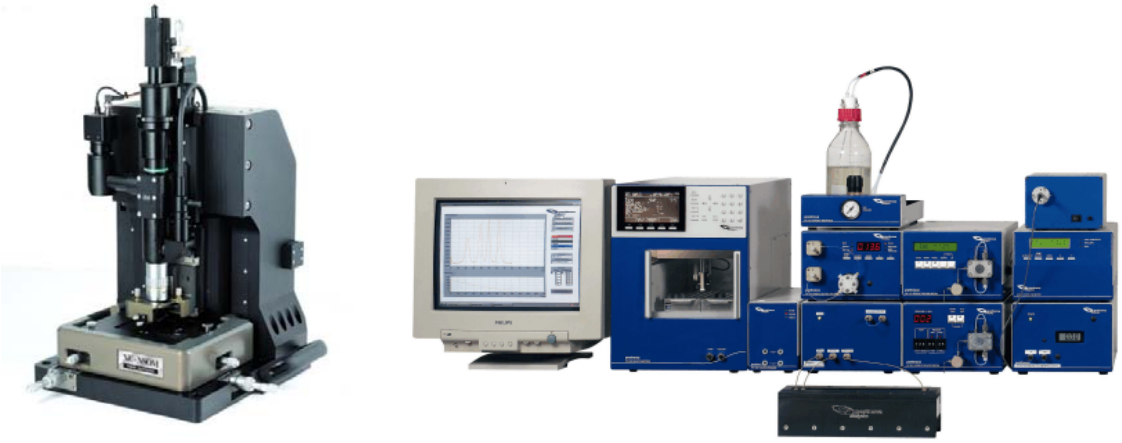

Figure 1. Images of atomic force microscope and flow field-flow fractionators used by FENAC, as part of a multi-method approach to nanomaterial characterisation. The AFM is housed within and an environmental chamber reducing noise and allowing variable atmospheric conditions. Work is performed in air or liquid. The FlFFF is non-destructive and size selected eluents can be analysed by microscopy, for elemental composition etc. Both instruments have sub-nm resolution and can be coupled to provide morphological particle data (shape and permeability).

SCIENCE HIGHLIGHTS

Collaboration with the University of Exeter (a5 grade for application) has resulted in productive research which is investigating the nanotoxicology of a range of NMs to freshwater fish, investigating bioavailability and biological effects. The projects have indicated that there is substantial uptake of NMs and even their aggregates via gills and especially gut and localisation within specific tissues. FENAC contributed by characterising the NPs as procured, in media and to a lesser extent in biological tissue. The results showed that supplier information was largely inaccurate, but good agreement was obtained between various sizing and other methodologies and the data provided allowed interpretation of the biological data produced by the Exeter team. Data production has been extensive and resulted in two publications with others to follow, a further FENAC application, one submitted NERC application (NERC/MRC EEHI programme) and one NERC standard grant project discussed (Dec 2010 submission).

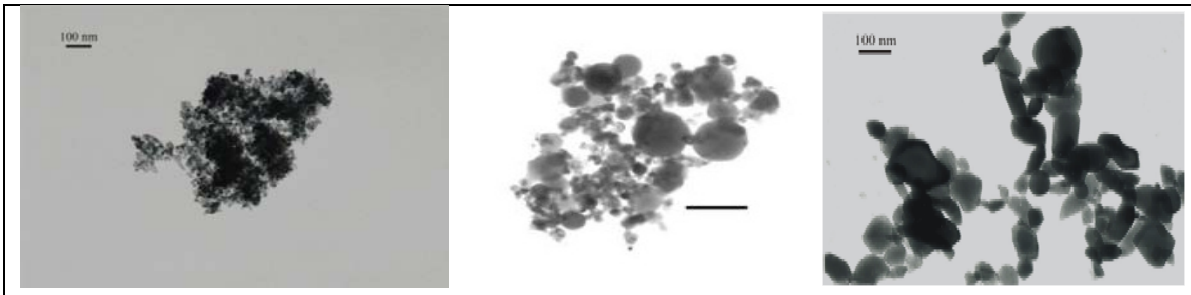

Figure 2. TEM images of manufactured nanoparticles of (from left to right) cerium oxide, titanium oxide and zinc oxide used in a comparative study of uptake and effects in fish.

Publications

T.M. Scown, R. Goodhead, B.D. Johnston, J. Moger, J.R..Lead, R. vanAerle, T. Iguchi, C. R. Tyler (2010). An assessment of cultured fish hepatocytes for screening cellular uptake and (eco)toxicity of nanoparticles. Environmental Chemistry, 7, 36-49.

T. M. Scown, E. Santos, B. D. Johnston, B. Gaiser, M. A. Baalousha, S. Mitov, J. R. Lead, V. Stone, T. F. Fernandes, M. Jepson, R. van-Aerle, C. R. Tyler (2010). Effects of Aqueous Exposure to Silver Nanoparticles of Different Sizes in Rainbow Trout. Toxicological Sciences (in press).

Collaboration with the Plymouth Marine Laboratory (a4 application) has investigated the comparative behaviour and uptake of dissolved iron and iron nanoparticles in estuarine conditions. Again, FENAC has provided underpinning information on NM physico-chemistry, to allow enhanced interpretation of ecotoxicological data performed at PML. The work has been published, has led to a further FENAC application and a NERC standard grant application in collaboration with FENAC (June 2010).

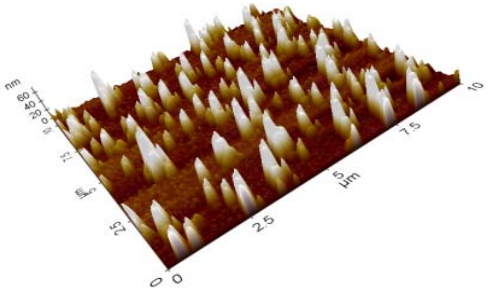

Figure 3. 3D atoimic force microscope (AFM) image of iron oxide nanoaprticles in synthetic seawater media.

Publications

E. Kadar, **J. R. Lead**, S. Mitov, S. Widicombe, J. W. Readman (2010). The influence of irradiation and aging on nano-iron versus its bulk analaogue in seawater. Geocimica et Cosmochima Acta (in press).

E. Kadar, F. Simmance, O. Martin, N. Voulvoulis, S. Widdicombe, S. Mitov, **J. R. Lead** and J. W. Readman (2010). The influence of engineered Fe_2O_3 nanoparticles and soluble ($FeCl_3$) iron on the development toxicity caused by CO_2-induced seawater acidification, Environmental Pollution (in press).

A number of method development studies have been performed. The first tested a multi-method approach (TEM, AFM, FlFFF, DLS, FCS, NTA) for the size analysis of several inorganic NMs in complex media, in collaboration with Canadian universities (Montreal and McGill). The second investigated the size, crystal structure and surface chemistry of cerium oxide NMs in ecotoxicological media, partly in support of an Australian (CSIRO) study quantifying ceria toxicity to algae.

Publications

R. F. Domingos, M. A. Baalousha, Y. Ju-Nam, M. Reid, N. Tufenkji, J. R. Lead, G. G. Leppard, K. J. Wilkinson (2009). Characterizing manufactured nanoparticles in the environment - multimethod determination of particle sizes. Environmental Science and Technology, 43, 7277-7284.

N. J. Rogers, N. M. Franklin, S. C. Apte, G. E. Batley, J. R. Lead, M. A. Baalousha (2010) Physico-chemical behaviour and toxicity to algae of nanoparticulate CeO_2 in freshwater. Environmental Chemistry, 7, 50-60.

Y. Ju-Nam, M.A. Baalousha, P. A. Cole, C. R. Tyler, V. Stone, T. Fernandes, M. A. Jepson, J. R. Lead (2010). Characterization of cerium oxide NPs. Part 1: size measurement by AFM, TEM, XRD, DLS and BET. (in prep)

M.A. Baalousha, Y. Ju-Nam, P. A. Cole, C. R. Tyler, V. Stone, T. Fernandes, M. A. Jepson, J. R. Lead (2010). Characterization of cerium oxide NPs. Part 2: non-size measurement. (in prep).

FUTURE DEVELOPMENTS/STRATEGIC FORWARD LOOK

FENAC will continue with the progress made to date in supporting the environmental and biological 'nano' community, in broadening its reach and access of the potential user community. Initial demand is high and FENAC will continue to meet these needs in particular in the NERC themes of Environment, Pollution and Human Health and of Technologies. The signs are promising with applications to FENAC increasing and a number of NERC responsive mode and thematic programme grants collaborating with FENAC. FENAC will continue to perform, improve and widen access to essential training via one-to-one laboratory training and summer schools, which also act as valuable outreach mechanisms. New instrumentation will be incorporated into FENAC, including access to the FCS (Birmingham and NERC S&F funding) and cryo STEM tomography being developed at Birmingham as part of the UK-US grant which is headed by Birmingham/Lead (NE/H013148/1).