Focke: Best research outputs in chemical and polymer technology from Student Supervision 2009 - 2016

Carbon technology

The original objective of the IAM research in carbon technology was to investigate the synthesis and characterisation of nuclear-grade graphite from local South African raw materials. This was initiated in support of the now defunct pebble-bed reactor project. Knowledge of the oxidation behaviour of nuclear graphite was considered important for the simulation of possible accident scenarios in pebble-bed reactors. PhD student Hein Badenhorst used high resolution electron microscopy and thermal analysis techniques to study the oxidation of graphite. He found that, even in graphite samples of highest purity, oxidation is still dominated by the effect of catalytic impurities [1]. He also developed mathematical models for the oxidation rate of graphite materials [1-4]. This work is now internationally acclaimed and launched Hein's academic career. He won numerous accolades and prizes for this work:

- Winner of the 2010 Carl Zeiss Nano Image Contest in the category Scanning Electron Microscopy (SEM).
- Best overall student presentation, Microscopy Society of South Africa, MSSA Conference, 2010.
- Second best student presentation, South African Institute of Chemical Engineering, SAIChE Student Symposium, 2010
- First place and runner-up prizes at the Southern African Science Lens Competition
- Selected to participate in the 63rd Lindau Nobel Laureate Meeting, 30 June to 5 July 2013, in Lindau (Germany).
- 2013 Keynote address: International Carbon Conference, July 2013. "Linking graphite particle micro-structure and reactivity" H. Badenhorst, B. Rand and W.W. Focke
- 2016 Keynote address: International Carbon Conference, Penn State University, USA, July 2016. "Graphite oxidation as a tool for microstructural investigation" H. Badenhorst
- 2017 Meiring Naude Medal from the Royal Society of South Africa.

Clay and polymer additive technology

PhD student Dan Molefe studied the use of magnesium hydroxide, hydromagnesite and hydrotalcite (a layered double hydroxide) as additives for polymers. Surface treatment with a fatty acid proved important for reducing the viscosity of filled liquids [5]. It turned out that layered double hydroxides provide a dual function to PVC simultaneously improving heat stability and fire retardancy [5-7].

Nanoclay dispersion in polymer matrices usually requires organo-modification with surfactants. PhD student Afonso Macheca managed to prepare polyamide nanocomposites that employed the polymer chains themselves for the required organo-modification and this led to materials with significantly improved stiffness [8-11].

The following students won awards:

- Puxley Mashele won the 2010 Chemical Technology Award in the category Environmental engineering to for his paper on stabilization of LDPE and HDPE films.
- Mia Ackermann received the first prize for her oral presentation at the SACS 2012 Chemometrics Conference held at Irene Country Lodge on 9 to 11 May 2012.
- Mthoko Sibanda's bicomponent repellent fibre malaria project has won a special prize in the 2016 GAP Competition. The prize was one year of free incubation at the Innovation Hub plus R170 000.

- Mthoko Sibanda and Tatenda Modzorera were finalists in the SAB Foundation social innovation awards 2016 competition for the bicomponent repellent fabric. They cornered a prize of R 150 000. http://www.africanappliedchemical.co.za/hello-world/

Pyrotechnics

For safety reasons, pyrotechnic compositions are nowadays prepared as slurries in water that are subsequently spray dried. The problem is that the silicon fuel reacts with water to form highly explosive hydrogen gas. Masters' student Shepherd Tichapondwa came up with three novel approaches to suppress the evolution of hydrogen gas in such aqueous silicon dispersions [12-14]. They include the use of silanes to hydrophobise the silicon surface [13], controlled thickening of the passive oxide layer on the silicon particle surface [12], and the introduction of a competing cathodic reaction in the slurry medium [14].

Copper antimonite is a very interesting oxidant that we discovered and patented [15]. According to AEL Mining Services it delivers highly insensitive compositions with silicon as fuel. We found a convenient new way to synthesising this interesting oxidiser [16]. PhD student Maria Atanasova managed to establish its unique crystal structure from powder XRD data and confirmed this via atomic modelling [17].

The references for this section and can be found on our web site: http://www.up.ac.za/institute-of-applied-materials-iam

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