Disciplinary Research and Creative Activity Presentations

Dr. Steven Bullock

Part Time Chemistry Professor-KSU

April 4, 2017

KENNESAW STATE UNIVERSITY

Proposed Research Activity

The area of my proposed disciplinary research will focus on nanotechnology materials and high temperature polymers. Aerospace R&D is implementing lightweight structure and materials to improve fuel efficiency. The highest need to replace heavy structure is in the engine environment where high temperature super alloys experience temperatures of 1250°C. This is the realm of preceramic polymers, poly(methyl-silazanes) and poly(borazine). The enabling chemistry is to develop a polymer structure that cures into a high temperature composite fiber and loses minimal volume during processing.

This research not only saves weight, but improves the ease of manufacturing, which has other broad industry applications. The high temperature polymer route is applicable to battery polyelectrolyte research as well. Recent news of batteries catching fire and utilizing polysilazanes for use as inflammable battery separators lends credence to this research pathway as an exciting opportunity for students to be exposed to ceramics. The polymer synthesis for preceramic polymers will also expose students to high temperature processes in inorganic-organic hybrid materials. The materials used are diborane or ammonia gas and vinyl silanes, are the reactions are straightforward for graduate students with experience in gas phase reactions.

These polymerization reactions are conducted in a stainless steel Parr reactor, with the reactants loaded and polymerization occurring via pyrolysis at approximately 500 to 700 °C (1995). These pyrolysis conditions are also feasible in standard Lindberg tube furnaces with quartz tubing. Polymers produced via these methods are characterized by TGA, or differential scanning calorimetry, followed by NMR and solid state NMR. XPS can also be performed via the Oak Ridge National Laboratory group to determine composition analysis of the polymeric products.

Batteries and ROMP

The following slides indicate my ability to conduct research with battery technology and perform chemistry research at Kennesaw State.

Macromolecules **2004**, *37*, 1783−1786

Synthesis of an A/B/C Triblock Copolymer for Battery Materials Applications

Steven E. Bullock[†] **and Peter Kofinas***[,‡]

Department of Materials Science and Engineering and Department of Chemical Engineering, University of Maryland, College Park, Maryland 20742-2111

Received November 6, 2003; Revised Manuscript Received January 2, 2004

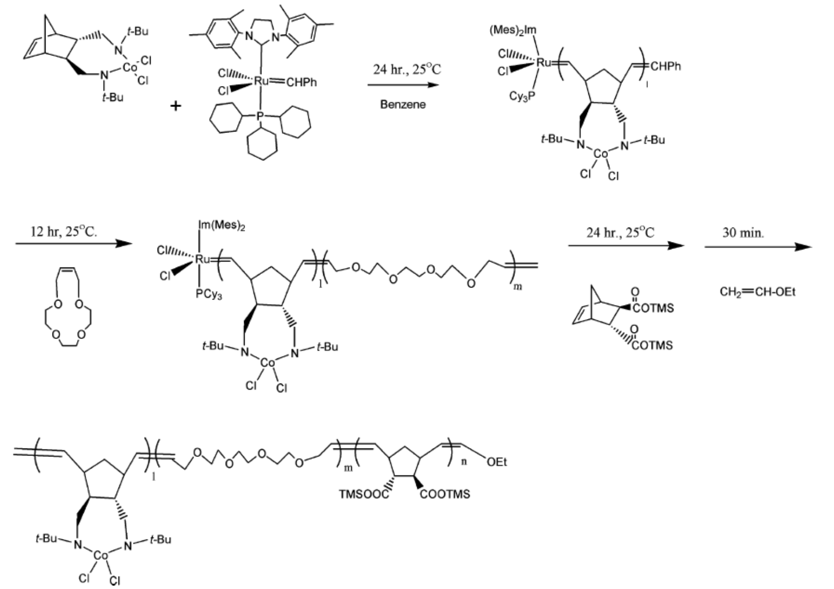


Figure 1. Synthesis schematic of $[NORCo]_{80}/[TOCD]_{150}/[NORCOOTMS]_{150}$ triblock.

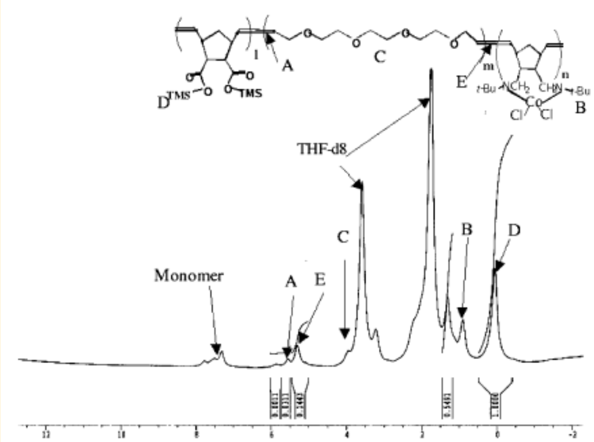


Figure 3. ^{1}H NMR of $[NORCo]_{80}/[TOCD]_{150}/[NORCOOTMS]_{150}$.

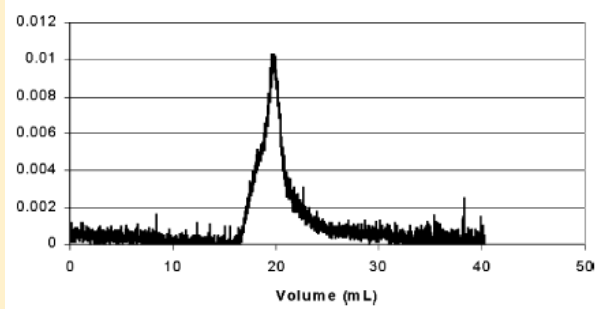


Figure 5. GPC trace of $[NORCo]_{80}/[TOCD]_{150}/[NORCOOTMS]_{150}$.

Scholarly Research with SPACE

The opportunity to share my own research within the KSU community and provide students with an opportunity to pursue areas of research not currently studied at KSU is a driving force. Exposure to the varied fields of science at the junction of different disciplines is where new research can be created by students. The following images are from my own graduate work, the first being a transmission electron microscopy of the block copolymer used on battery development. The scale bar represents 125 nm. The next image is XPS, X-ray photoelectron spectroscopy, which performs elemental analysis of the sample.

ELSEVIER

Available online at www.sciencedirect.com

SCIENCE DIRECT

Journal of Power Sources 132 (2004) 256–260

JOURNAL OF POWER SOURCES

www.elsevier.com/locate/jpowsour

Short communication

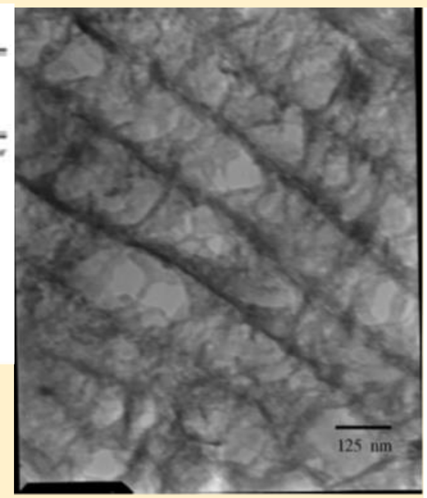
Nanoscale battery materials based on the self-assembly of block copolymers

Steven E. Bullock[a], Peter Kofinas[b,*]

[a] Department of Materials Science and Engineering, University of Maryland, College Park, MD 20742-2111, USA

[b] Department of Chemical Engineering, University of Maryland, College Park, MD 20742-2111, USA

Received 3 December 2003; accepted 17 December 2003



Transmission electron microscopy (TEM)

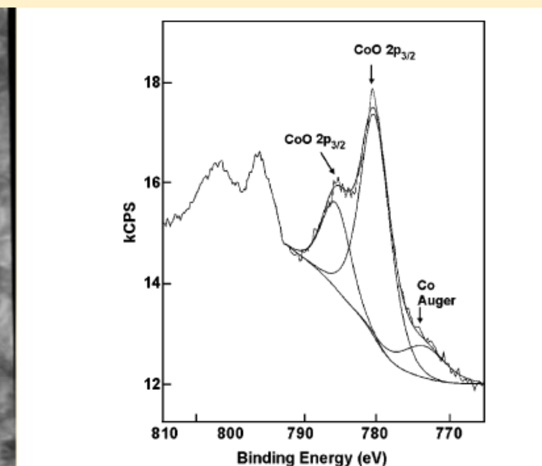


Figure 4. XPS of static cast triblock copolymer films.

X-ray Spectroscopy (XPS)

Battery Cycling, Ionic conductivity, Amperage

The data below are the ionic conductivity with respect to temperature, and cyclic voltammetry to determine the cycle response to a charge and discharge cycle. The battery was cycled 300 times, to determine the stability of the electrolyte and cathode materials.

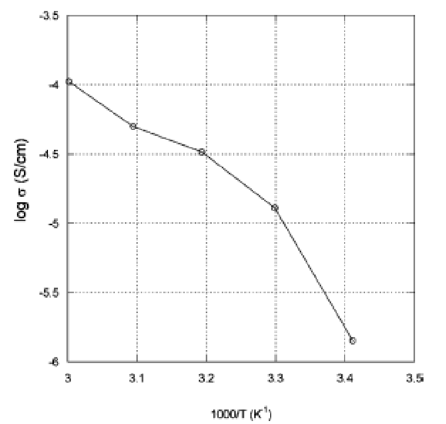


Fig. 4. Impedance spectra of (NORCOOH/TOCD) diblock with $LiClO_4$.

Ionic conductivity of TOCD

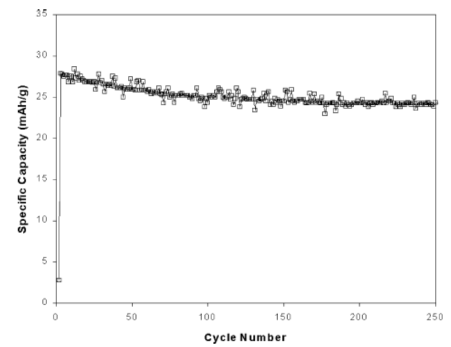


Fig. 6. Galvanostatic testing of lithium battery based $LiMn_2O_4$ composite cathode.

Amperage cycling for battery performance

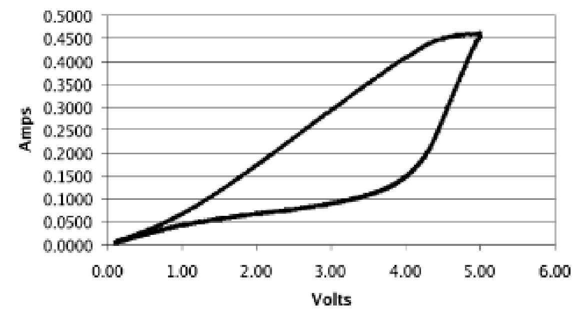


Fig. 5. Cyclic voltammetry of $LiMn_2O_4$ composite cathode.

Amperage cycling for battery performance

Polydispersity control in ring opening metathesis polymerization of amphiphilic norbornene diblock copolymers

Sufi R. Ahmed[a], Steven E. Bullock[a], Arthur V. Cresce[a], Peter Kofinas[b,*]

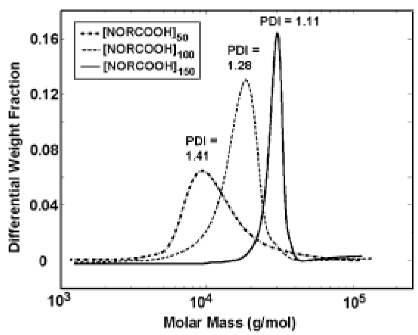


Fig. 2. Molecular weight distribution of homopolymers of NORCOOH ([NORCOOH]$_n$, n = 50, 100, and 150).

Decreasing polydispersity

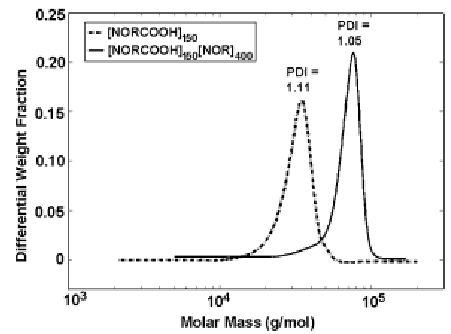


Fig. 6. Molecular weight distribution of [NORCOOH]$_{150}$ and [NORCOOH]$_{150}$[NOR]$_{400}$.

Narrow Polydispersity of functional groups

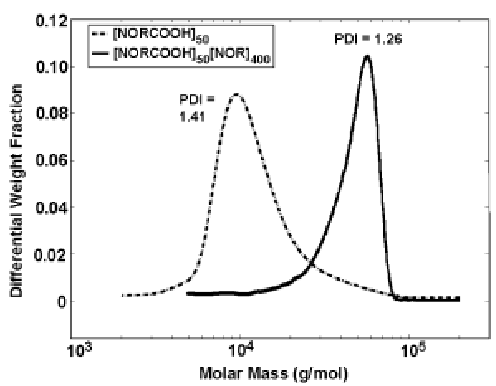


Fig. 4. Molecular weight distribution of [NORCOOH]$_{50}$ and [NORCOOH]$_{50}$[NOR]$_{400}$.

Order of Addition
Polymerization
Shifts kinetics

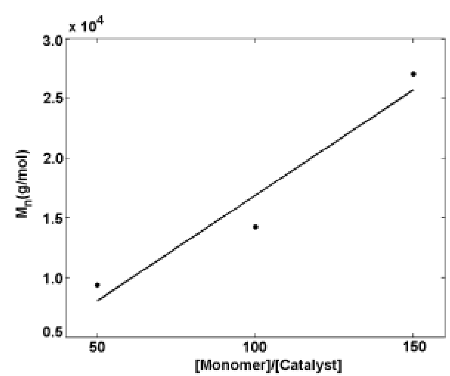


Fig. 7. Graph of number average molecular weight and the catalyst to monomer ratio.

Living
Polymerization
Linear
C/M ratio

Kennesaw State University

Original Research Concepts for SPACE

As part of the scholarly activity for part time faculty, I also teach upper level undergraduate courses, and feel this research opportunity provides a focused conduit to work one-one with students with in interest in advanced technology, nanotechnology and materials science.
This disciplinary scholarship can allow me to interface with students and provide valuable insight into learning science and engineering within industry and collaborating at the workplace.

Other topics for research could include biobased materials for a collaborative KSU bimolecular and chemistry workshop for students.
I can provide visual presentations and demonstrations that will encourage STEM participation for KSU students.