MSEC Seminar, June 6, 2014

Ceramic liner for Increased Thermal Stability of Machine Gun Barrels

ABSTRACT

The ceramic coating on the steel appears to be crystalline. Analytical quality x-ray scattering with our Bruker AXS D8 Focus indicates the presence of carbon nitride (C_3N_4) and no indication of silica nitride or silica carbide. Because the coating is thin (approximately 10 μm), the x-ray beam could penetrate the coating and detect the steel below. Evidence will be provided that demonstrates that the x-rays do not penetrate the ceramic coating. The WAXS of the ceramic coating prepared from the polysilazane KiON HTT 1800 with 5% by weight of hollow nanotubes (HNT) indicates no apparent discernable difference between the WAXS with and without the HNT. This is reassuring in regard to the suspected chemistry occurring for the preparation of the ceramic coating not changing with 5% HNT present in the 1800. The ceramic coating prepared from 1800 with 5% HNT has superior hardness to the ceramic coating prepared with 1800 without the HNT. The presence of C_3N_4 based on WAXS is a surprise based on the available literature. This compound is extremely hard and is considered a suitable replacement for diamond in oil well drill bits, for example. The difficulty in utilizing C_3N_4 for these applications is associated with the major challenge of preparing the compound commercially. We suspect that the combination of the reaction of 1800 with the steel (based on WAXS evaluations) and the generation of C_3N_4 presents a unique ceramic coating not expected from the open literature with unusually superior performance juxtaposition to other ceramic coating systems for machine gun barrels. EDS evaluations by SEM indicates that the silica is located on the surface of the ceramic coating. Live fire evaluations of 5.56 mm and 7.62 mm rounds indicate excellent performance for 36 rounds. 500 round rapid fire evaluations indicate that the chrome liner (the control barrel) and the ceramic liner are compromised.

ABSTRACT FOR MSEC PRESENTATION SCHEDULED FOR JUNE 6, 2014

VIOLATION OF THE PHYSICS OF DISPERSED PHASE REINFORCEMENT IN THERMOPLASTIC POLYURETHANE-MONTMORILLONITE NANOCOMPOSITE ELASTOMERS

The need for improved toughness in elastomer seals for oil field equipment devoted to fracking is critical. The thesis of this work is that thermoplastic polyurethanes can outperform two

package urethanes with regard to toughness and are more suitable for the successful preparation of montmorillonite nanocomposites. A formula containing a superior thermoplastic urethane and an organomontmorillonite provides an order of magnitude improvement in mechanical performance with a percent elongation to failure that cannot be readily determined. Details of the formula will be provided. Mechanical performance measurements of the nanocomposite will be provided. This magnitude in improved toughness successfully addresses the needs for improved durability for elastomer seals in the oil business.

SHORT BIOGRAPHY FOR THE FRIDAY JUNE 6, 2014 COMMERCIALIZATION FORUM AND TECHNICAL SEMINAR

B. Educational Background

Degree	Year	University	Major	Thesis/Dissertation
B.S.	1966	California State University Long Beach	Chemistry	
M.S.	1969	California State University Long Beach	Organic Chemistry	Asymmetric Induction in Epoxy Ring Openings
Ph.D.	1979	Rutgers University	Organic Chemistry	Some Reactions of Syn- and Anti-Phenylethane Diazotate

. Relevant Professional Experience

Position	Entity	Dates
Senior Scientist	**Southern Clay Products, INC.**	**1993-2004**
Director, Polymer Research and Development	**The Sherwin Williams Company**	**1988-1993**
Section Leader/Physics and Latex Groups	**The Sherwin Williams Company**	**1986-1988**
Group Leader, Latex Group	**The Sherwin Williams Company**	**1986**
Member of Isoset Adhesive Business Team	**Ashland Chemical Company**	**1985-1986**
Senior Research Chemist II	**Ashland Chemical Company**	**1981-1985**
Senior Research Chemist	**Ashland Chemical Company**	**1980-1981**

Senior Chemist	**Glidden Paint Company**	**1979-1980**
Chemist I	**Glidden Paint Company**	**1976-1979**

Books

Beall, G. W.; Powell, C. E.; "Fundamentals of Polymer-Clay Nanocomposites" pub. Cambridge University Press, (2011).

Chapter 33, Physical Properties of Polymer/Clay Nanocomposites. *Physical Properties of Polymers Handbook,*Springer Berlin Heidelberg New York, 2nd ed. 2006.

Resent Refereed Journal Articles:

1. Study of the structure-property relationships in a high impact and shape memory polyester by the stereoisomer selection of the cyclobutane diol monomer, *Journal of Materials Science* (2013), **48**(24), 8588-8595.
2. Shape memory polymers based on CBDO: structural recovery effects, *Annual Technical Conference-Society of Plastics Engineers* (2008) 66th 743-745.
3. Chemistry of Mechanical Performance: Memory, Self-Healing Behavior, and High Impact Resistance in Nanocomposites, *SAMPE Fall Technical Conference* (2008), 40th ISTC
4. Physical properties of CBDO based co-polyterephthalate nanocomposites. *Applied Clay Science,* 37, 295 (2007).
5. Physical properties of polymer/clay nanocomposites. *Current Opinion in Solid State and Material Science*, 10, 73 (2006).

Recent Patents:

1. WO 2012167218 A2 Electrode device and method for identifying and counting microbes and for
2. Determining antimicrobial sensitivity
3. US 8,637,233 (2014) Device and Method for Identifying Microbes and Counting Microbes and
4. Determining Antimicrobial Sensitivity
5. US 8,092,128 B1 Self-Sealing Fastener covered with moisture-curable sealant
6. PCT/US/2011/048106 Durable Ceramic Nanocomposite Thermal Barrier Coatings for Metals and Refractories

Awards & Honors:

1. Corporate Scientific Achievement Award - 1992 and 1993 (the most prestigious technical award at Sherwin Williams).
2. Cost saving award - 1992 (from the International Group at Sherwin Williams)
3. Central Research Laboratory Scientific Merit Award - 1987 (Sherwin Williams)
4. Most Cited Article from 2006-2010 for Current Opinion in Solid State and Materials Science.
5. Rated as the top 20% of the reviewers for Journal of Physical Chemistry.

6. Rated as the top reviewer for the journal Polymer.
7. 2014 Co-operative Research Award of the Polymer Materials Science and Engineering Division of the American Chemical Society.

Bert Powell (Corporate Scientific Achievement(most prestigious technical award at Sherwin Williams), Cost savings award (International Group at Sherwin Williams), Central Research Laboratory Scientific Merit Award (Sherwin Williams)), was lured away from Sherwin-Williams to Southern Clay Products at the end of 1993 to develop a product line for the anticipated new market of polymer-montmorillonite nanocomposites. His industrial perspective and experience with coatings and adhesives accelerated the development of novel material and processing solutions for different market segments, ranging from olefins, sheet molding compounds, and transportation, to cosmetics, food packaging and flame retardancy. A search of the product line, Cloisite (named after Dr. Clois Powell), designed by SCP for polymer nanocomposites lists over 5,000 references focused on specific implementation protocols, innovations, and commercial products. Far too many references to be documented here. Recent history has sharpened the focus on this team, and its incredible contribution to the science and industry of next generation polymers for light weight transportation, improving energy efficiency of buildings, advanced firearm technology, high performance ceramic coatings for metal, and expanding the cutting edge of aerospace technologies.