Investigating The Environmental Stability of Ballistic Fibers Using Model Compounds and Mass Spectrometry

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Introduction

• Ballistic-resistant body armor has been credited with saving more than 2500 lives in the United States.

• New lighter-weight, higher-strength materials are constantly being developed.

• There currently exists no method for evaluating the effects of environmental aging on body armor to ensure the continued effectiveness of the protection.

• Physical reliability under mechanical fatigue and a wide variety of environmental conditions is a critical design requirement.

•Primary Functions of Protective Body Armor:

- Minimize Energy Dissipation of Impacting Projectile
  - Back Face Signature
- Stop Projectile Motion
  - Trampoline Effect

Goal

To develop metrologies and predictive models to test and predict the long-term reliability of polymers used in ballistic resistant armor

Polybenzoxazole (PBO) Chemistry

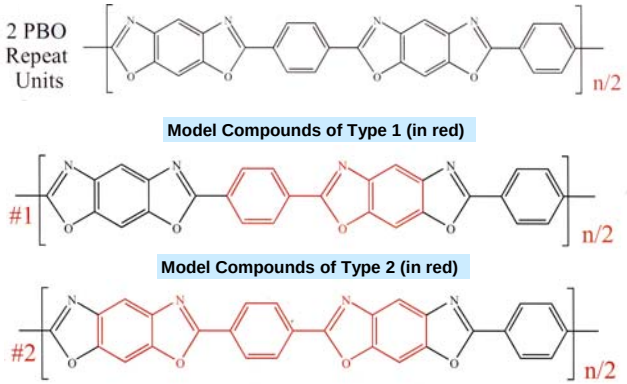
- Identify chemical mechanisms underlying reduction of ballistic performance, i.e., UV exposure and hydrolysis
- Steps:

1) Model compound preparation

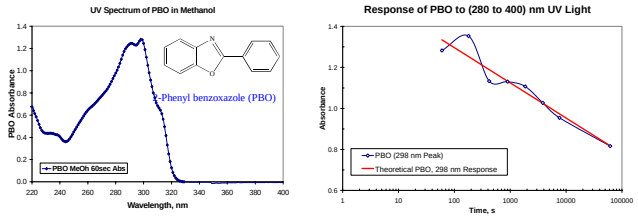
2) Degradation analysis:
MALDI-MS, FTIR, NMR, & UV-Vis

3) Identify spectral "fingerprints" of degradation

Basic PBO Repeat Unit and PBO Model Compounds for Study



PBO UV absorption peak intensity declines with UV radiation



Preliminary Results

• To study the UV degradation PBO and Model Compounds must be dissolved in a *common solvent*

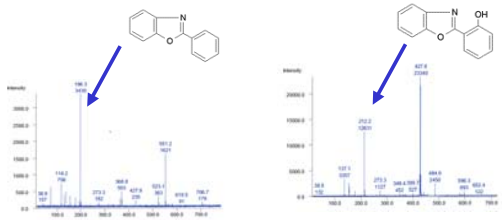
• Only common solvent found so far for these four compounds is formic acid

• MALDI spectra using 2,5-DHB as the matrix of the four model compounds are shown below

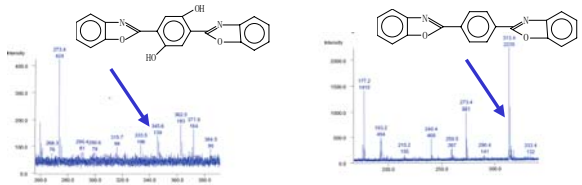
• Best spectra were found using a surfactant as a matrix suppressor

• Surfactant used was tributylhexadecylphosphonium bromide

MS Spectra of Type 1 Model Compounds



MS Spectra of Type 2 Model Compounds



Note: Due to solubility issues the Type 2 compounds would not go into formic acid at high concentration, this lead to lower intensity, when compared to the matrix peaks, for these compounds in the MALDI spectra.

Reference

G.A. Holmes, K. Rice, C.R. Snyder, "Ballistic Fibers: A Review of the Thermal, Ultraviolet and Hydrolytic Stability of the Benzoxazole Ring Structure," submitted to *The Journal of Materials Science*