IONIC AGING AND THE SHELF-LIFE OF BALLISTIC SELF-HEALING IN IONOMERS

S. J. Kalista, Jr. [1,2], J. R. Pflug [3] and R. J. Varley [4]

[1] *Department of Mechanical Engineering, Union College, 807 Union St, Schenectady, NY 12308, USA – e-mail: kalistas@union.edu*
[2] *Macromolecular Science and Engineering, Virginia Tech, Blacksburg, VA 24060 USA – e-mail: skalista@vt.edu*
[3] *Department of Physics and Engineering, Washington and Lee University, 204 W Washington St, Lexington, VA 24450 USA – e-mail: pflugj10@mail.wlu.edu*
[4] *CSIRO Materials Science and Engineering, Private Bag 33, Clayton South, Victoria 3169, Australia – e-mail: Russell.Varley@csiro.au*

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ABSTRACT

Poly(ethylene-*co*-methacrylic acid) (EMAA) copolymers and ionomers possess the unique ability to autonomously self-heal following ballistic puncture. Given this response, these materials hold significant potential for use in a range of applications including fuel tanks, pressurized environments or containment applications. While the mechanism has previously been assumed the result ionic content, it has been shown that hydrogen-bonding within the non-ionic precursor copolymer produces the same response. However, given changes in morphology upon aging, the self-healing ability may diminish with time.

A range of EMAA copolymers and ionomers having zero, moderate, and high ionic content were examined using various characterization techniques including FTIR, DSC, DMA, tensile, and ballistic puncture testing. Puncture tests below the order-disorder transition, T_i (~40°C), showed moderate ionic content the most successful in self-healing with neither non- nor high ionic varieties successful at very low temperatures. Above T_i, all varieties were successful, with moderate and highly ionic materials healing into the melt state. Overall, ballistic healing persisted over a wide range from -50°C to 130°C. By correlating this response with standard characterization methods, it was determined that the increased rigidity of ionic clusters inhibited the necessary elastomeric nature of the healing response at low temperatures, yet provided the strength to maintain elasticity into the melt state.

However, success of the healing response was shown to be dependent on age post melt processing. Physically, ionic and hydrogen-bonded domains present in EMAA materials appear to order with age when held below T_i. Ballistic tests on these materials over several months showed a clear loss in self-healing response in the most ionic varieties, while those less ionic varieties remained consistently successful. Ultimately, this suggests a shelf-life for self-healing in the most ionic materials, which provides further understanding of the healing mechanism and must be considered in future studies or prospective commercial applications.