Northeast GAS ASSOCIATION

NYSEARCH

Technology Brief

Next Generation Advanced or Self-Healing Plastic Pipe for Natural Gas Applications

Description: **A project dedicated to using new materials technology towards the development of the next generation of plastic pipe and self-healing for natural gas piping applications**

Status: **Feasibility study is underway to determine which properties will be incorporated in new advanced plastic pipe materials**

BENEFITS

Plastic pipe is the material of choice for natural gas distribution systems. While reliable and durable, like all underground facilities, plastic pipe is exposed to threats of encroachment and in particular third party damage. Efforts to further advance the mechanical properties, enhance resistance to slow crack growth and to add self-healing capabilities to the pipe will improve reliability of the delivery system and overall life. Such improvements would further improve safety and potentially reduce the cost associated with maintenance and safety of the natural gas distribution system. In addition, if the plastic pipe had enhanced electrical properties, we could make a quantum leap in advancing plastic pipe with smart systems to monitor for changes in the pipe condition for situations like third party encroachment. We could also then have better success transferring signals and information along and through the plastic pipe material.

BACKGROUND

Polyethylene is widely used for pipes in the natural gas distribution system due to its light weight, flexibility, resistance to environmental threats, good resistance to crack growth, ease of installation, relative ease in incorporating fittings into a piping system and low cost. Polyethylene and closely related resins are expected to continue being the dominant materials for the industry as the distribution system grows over the next decades.

However, there are some opportunities with plastic pipe that users would like to continue to advance in order to further improve its performance. In addition, new technologies that are now available to the natural gas industry could be applied in plastic pipe systems if additional properties were present. The material parameters of increased tensile strength and Young's modulus (Figure 1) could allow operation at higher pressures. Increased impact resistance could extend life and prevent early failure. Addition of electrical conductivity and magnetic properties could allow the use of the pipe to power distributed sensor systems that are attached to the pipe and provide location

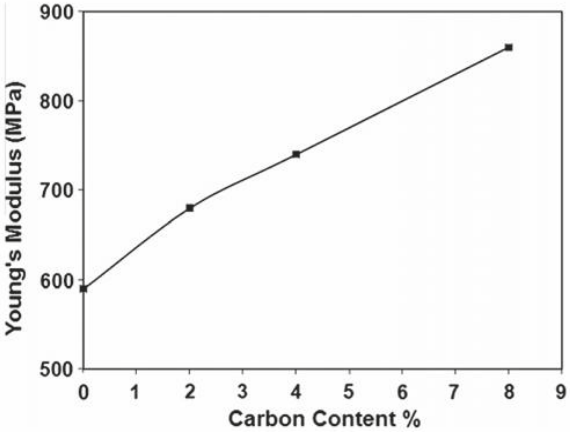

Figure 1: *Influence of carbon nano-particles percentage on Young's modulus of HDPE matrix* **(**from Characterization and processing of high density polyethylene/carbon nano-composites. H. Fouad, Rabeh Elleithy, S. M. Al-Zahrani, Mohammad Al-haj Ali. Materials and Design, Vol. 32 , 2011, pp1974-1980).

capabilities from above ground. Finally, the introduction of self-healing capabilities would allow plastic pipe to repair itself when compromised due to third party damage, thus eliminating the need for expensive and intrusive repair work.

TECHNICAL APPROACH

NYSEARCH undertook a systematic review of the pertinent materials literature to determine the state of the art in materials science of polyethylene materials. In particular, work in the emerging field of nanomaterials was surveyed to identify new polyethylene-based materials with improved properties. Nanomaterials are materials formed through the introduction of nanoparticles, nanofibers or carbon nanotubes in engineering materials to produce new materials with altered mechanical and other properties. A significant body of work was identified in this area that showed that nanomaterials using polyethylene as their basic (matrix) material and incorporating various types of nanoparticles (fillers) can indeed offer improved properties on various fronts. Nanoparticles can improve the mechanical properties, such as tensile strength and modulus of a HDPE matrix, as shown in Figure 1 where dramatic increases in the value of Young's modulus of elasticity are demonstrated. Nanoparticles can also improve the electrical conductivity of a HDPE matrix and introduce magnetic properties; and certain nanoparticles can improve resistance to slow crack growth.

In addition, work with other plastic materials as matrices indicated that self-healing properties can be introduced in such materials. While a few different approaches have been experimented with regarding the introduction of self-healing properties, the concept of incorporation of microcapsules containing a polymer precursor into the matrix material offers the highest promise. As can be seen in Figure 2, the matrix contains a randomly dispersed catalyst that reacts with the precursor, flowing through any crack formed due to damage, and initiates polymerization. The polymer bonds the crack face closed, with researchers being able to show to date recovery of up to 75% of the maximum tensile strength of the virgin composites.

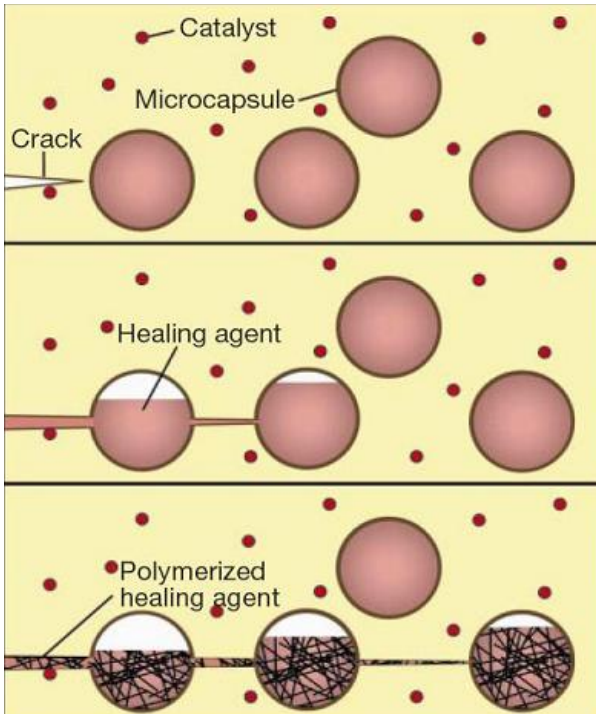

Figure 2: Microencapsulated self-healing concept (from Autonomic healing of polymer composites. S. R. White, , N. R. Sottos, P. H. Geubelle, J. S. Moore, M. R. Kessler, S. R. Sriram, E. N. Brown and S. Viswanathan. Nature 409 (2001), pp794-797).

Based on these results, a feasibility study is being carried out to explore the possibilities of developing new HDPE-based materials with enhanced mechanical and slow growth properties, materials that have electrical and magnetic properties, and materials with self-healing properties. Various material options are being examined, while manufacturing and cost issues are being considered.

PROGRAM STATUS

With the conclusion of the literature review, a feasibility study is being initiated. The feasibility study will be followed by a selection of the most promising technologies for new materials. Currently, NYSEARCH is planning to partner with resin and pipe manufacturers to develop new commercial products to meet the project specifications.

For more information contact:
admin@NYSEARCH.org