

Product Formulations Using Recycled Tire Crumb Rubber

Federal Manufacturing & Technologies

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KCP-613-6044

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Published February 1998

Final Report/Project Accomplishments Summary
CRADA Number 96-KCP-1038

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Prepared Under Contract Number DE-AC04-76-DP00613 for the
United States Department of Energy

AlliedSignal

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A prime contractor with the United States
Department of Energy under Contract Number
DE-AC04-76-DP00613.

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KCP-613-6044
Distribution Category UC-706

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Date: 9/30/97

Revision: 0

A. Parties

The project is a relationship between:

AlliedSignal FM&T
2000 E 95th Street
PO Box 419159
Kansas City, MO 64141-6159

Recycled Rubber Resources
1600 Blees Industrial Drive
Macon, MO 63552

B. Background

Approximately 250 million automotive and truck tires are discarded each year in the U.S. The very properties that ensure a safe ride, puncture resistance, and a long service life make the disposal of these scrap tires difficult. In spite of this, scrap tire recycling/reuse has rapidly grown from a low of 10% in 1985 to over 90% today. The majority of scrap tires that are recycled/reused are burned for fuel in power plants and cement kilns. Since tires have somewhat higher heating value than coal, this would at first seem to be an acceptable option. But burning scrap tires recovers only 25% of the energy originally used to manufacture the rubber. Plus the high cost of collection and transportation requires regional combustion sites.

An alternative is to use the scrap tires in the form of crumb rubber, in which 98% of the original energy is recovered. This project sought to explore potential formulations of crumb rubber with various thermoplastic binders, with one goal being developing a material for a low-cost high-performance roofing composition.

C. Description

The objective of this project was to combine crumb rubber and synthetic fiber obtained from scrap tires with thermoplastic polymers and convert these materials into commercially useful, high-value products. A specific goal was to use these materials for roofing, while remaining cognizance of other potential applications.

Personnel at AlliedSignal FM&T focused on developing formulations and preparing mechanical and thermal test specimens using crumb rubber and synthetic fiber combined with thermoplastic binders. Recycled Rubber Resources personnel were to take information developed by AlliedSignal and focus on prototype building and product development, guided by requirements

and industry standards for roofing materials.

Test samples were injection molded at FM&T using crumb rubber as a filler for high density polyethylene (HDPE) and Nylon 6/10. The crumb rubber was mixed with the thermoplastics pellets (30% crumb rubber/70% resin), then manually fed into the screw feed port of the injection molding equipment, heated to the appropriate temperature for the particular resin in use. Thus the thermoplastic pellets were heated, melted, and uniformly mixed with the crumb rubber.

A similar process was used in blending synthetic fiber from the scrap tires with the same thermoplastic resins, in varying ratios from 10 to 30%.

Finally, crumb rubber was mixed with various concentrations of soybean oil and compression molded into 1/8 inch thick x 4 inch diameter discs.

Results

In general, adding crumb rubber to HDPE or nylon resulted in a slight reduction of mechanical properties such as tensile and flexural strength. The coefficient of thermal expansion was also slightly affected, primarily when added to the HDPE. The following summary tabulates the testing results.

Mechanical Tests

	<u>Tensile Strength</u>	<u>Tensile Modulus</u>
HDPE	2,990 psi	160,000 psi
HDPE/30% rubber	2,590 psi	130,000 psi
Nylon	6,750 psi	220,000 psi
Nylon/30% rubber	4,960 psi	270,000 psi
Nylon/50% rubber	3,340 psi	110,000 psi
	<u>Flexural Strength</u>	<u>Flexural Modulus</u>
HDPE	2,880 psi	150,000 psi
HDPE/30% rubber	2,250 psi	100,000 psi
Nylon	6,220 psi	220,000 psi
Nylon/30% rubber	7,160 psi	270,000 psi
Nylon/50% rubber	2,760 psi	140,000 psi

Thermal Expansion Coefficients

	<u>CTE</u> <u>-40 to 25°C</u>	<u>CTE</u> <u>25 to 100°C</u>	<u>CTE</u> <u>100 to 150°C</u>
HDPE	156 ppm/°C	---	---
HDPE/30% rubber	116 ppm/°C	203 ppm/°C	441 ppm/°C
Nylon	90 ppm/°C	154 ppm/°C	220 ppm/°C
Nylon/30% rubber	100 ppm/°C	173 ppm/°C	277 ppm/°C
Nylon/50% rubber	100 ppm/°C	163 ppm/°C	266 ppm/°C

While a reduction in properties was not totally unexpected, an interesting note was a possible interaction between crumb rubber and nylon. In molding the rubber and HDPE, the test specimens possessed a distinct smell, reminiscent of burnt rubber. However, the molded test specimens containing rubber and nylon were noticeably less odorous than the HDPE/rubber specimens, suggesting that a chemical reaction was taking place during the melt/extrusion process. This may be supported by the mechanical test results of 30% crumb rubber/nylon samples, in which the flexural strength and modulus measurably increased.

Test samples prepared from synthetic tire fiber with HDPE and nylon provided less satisfactory results. Because of the long fiber length, this material could not be directly injection molded. Instead, the thermoplastic resin was mixed with the fiber by the screw with the barrel heated and the check valve at the tip of the nozzle removed. The mixed material was then chopped up and compression molded into test bars. Percentages of fiber ranged from 10% to 30%. The test samples were tested for tensile strength and found to drop off roughly in proportion to the mix ratio. In an attempt to improve bonding between the fibers and resin, the fibers were dried first to remove moisture. This had little or no effect on the strengths. Time did not permit further investigation of surface treatment techniques such as gas plasma or the addition of sizing agents.

An interesting combination was soybean oil and crumb rubber. In this case, soybean oil was added to crumb rubber in varying proportions from 10 to 30%. Then the mix was compression molded at 350°F for an hour. The crumb rubber possessed enough reactive sites to cure into a relatively strong rubber. The soybean oil contains enough unsaturated carbon-carbon bonds to react with the rubber and serves as a plasticizer, softening the molded rubber sample.

D. Expected Economic Impact

This project has provided potential material formulations using ground crumb rubber and thermoplastic resins. In the case of HDPE, not only the crumb rubber but also the thermoplastic resin can be obtained from recycled materials. In the case of nylon, the resulting formulation will be more expensive because of the resin, but the combination may provide improved material properties in terms of strength and durability. Tires burned for fuel possess roughly the value of coal, or about 1 cent/lb. Tires ground for the crumb rubber have a value more on

the order of 15-25 cents/lb. Obviously, finding uses for crumb rubber is beneficial.

Adding soybean oil to the crumb rubber also provides unique material properties. Attributing an economic value to this combination of materials is speculative at this point without further development and market research into potential products.

E. Benefits to DOE

This project has enhanced the skills of FM&T technical staff in areas of composite fabrication including particle separation, rubber compounding, extrusion, compression molding, and injection molding. Materials developed during this project have the potential for application in WR programs. Incorporating crumb rubber particles in thermoplastics effectively toughens the plastic, similar to CTBN-toughened epoxys now used in encapsulants. The soybean oil additive to rubber has the potential for WR product by enabling modification to the durometer of rubber with the use of a non-toxic plasticizer. This work also complements FM&T's Quality policy goals of respecting the environment and reducing waste, gaining practical knowledge and additional expertise in this area.

F. Industry Area

The industries benefiting from this project include the automotive (crumb rubber in new tires), railroad (synthetic fiber in brakes), basic steel (remelting scrap steel wire), and manufacturers of molded rubber articles.

G. Project Status

This project was completed as scheduled.

H. Point of Contact for Project Information

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I. Company Size and Point of Contact

Recycled Rubber Resources is a small business of approximately 40 employees. The point of contact at Recycled Rubber Resources is Matt DeBasio [(816) 385-7156]. The crumb rubber production of RRR initially was 15,000 pounds per month. Steady improvements in grinding and separation processes have enabled crumb rubber production to increase to the current levels in excess of 1 million pounds/month. This level of production has enabled the company to expand to three working shifts.

J. Project Examples

During the course of the project, test specimens have been molded using crumb rubber in combination with agricultural-based plasticizing oils and thermoplastic resins. Since most of the specimens were destructively tested, a very limited number of these samples are available.

K. Technology Commercialization

Recycled Rubber Resources has continually sought outlets for their various grades of materials generated at their plant. A long-term goal is to develop a product that would be made on site using crumb rubber or fiber, but no product commercialization plans have been formulated at this time.

L. Release of Information

I have reviewed the attached Project Accomplishment Summary prepared by AlliedSignal FM&T and agree that the information about our CRADA may be released for external distribution.

Matthew C. DeBasio

1-29-98

Name: Matthew C. DeBasio Date

Organization: Recycled Rubber Resources, LLC

Title: President/CEO

M98052125



Report Number (14) KCP -- 613 - 6044

Publ. Date (11) 199802
Sponsor Code (18) DOE/DP, XF
UC Category (19) UC-706, DOE/ER

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