End-of-life gel cables: characterization, basic research and recycling potential

D.Sojka[1,2], K. Pikoń[2], K. Klejnowska[1], M. Lewandowska[1], T. Warski[1]. K. Suchoń[3]

[1]Łukasiewicz Research Network, Institute of Non-Ferrous Metals in Gliwice, Poland

(E-mail: dawid.sojka@imn.lukasiewicz.gov.pl)

[2]Silesian University of Technology in Gliwice, Poland

[3]Łukasiewicz Research Network, Institute of Engineering of Polymer Materials and Dyes Paints and Plastics Center in Gliwice, Poland

Introduction

Recycling gel cables is a challenge faced by recycling companies. Gel cables are filled with hydrophobic gel, which provides moisture protection for the cable's copper core. This type of cable is used, among other things, as telecommunications cables laid in areas exposed to moisture. The hydrophobic gel used is a serious problem in the cable and wire recycling process because it contaminates the end products.

The rest of the article describes the morphology of gel cables and the methods currently used to process them. Also presented are differential thermogravimetric thermal analysis and viscosity tests.

The issues discussed in the article are essential knowledge in the development of appropriate technology for the recovery of all raw materials included in these cables.

Basic research

Viscosity

Rheological behavior of the petrogel was analyzed by using a rheometer Lamy Rheology RM 200 with MS DIN 11S measuring system with sample volume 27 ml and EVA MS DIN PLUS temperature control. The rheological tests were conducted within a temperature range of 80-100°C and a shear rate varied from 0.1 to 500 s−1.

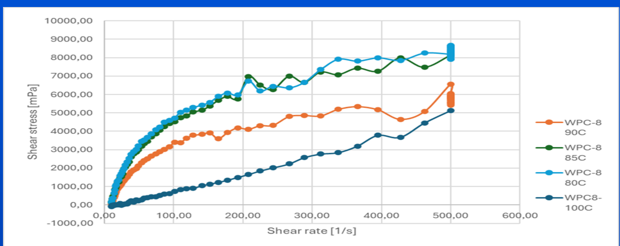

Figure 1: Petrogel flow curve in the temperature range of 80-100°C.

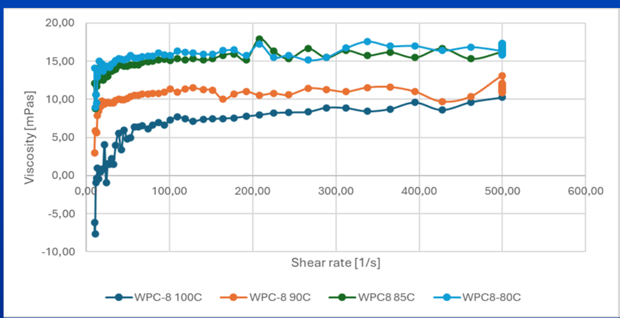

Figure 2: Viscosity curve in the temperature range of 80-100°C.

The rheological characteristic of petrogel WPC-8 is strongly dependent from temperature. The correlation between the shear stress and the shear rate is nonlinear in the temperature range 80-90C (figure 1), the emulsion exhibits a non-Newtonian liquid characteristic with shear thickening behavior flow curve (figure 2).

Viscosity curve show exhibits a non-Newtonian liquid characteristic with shear thickenning behavior flow curve (figure 3). With temperature increase material showed an increasing tendency toward shear thinning effect and highest shear thinning effect is observed at 100°C.

Analysis DTA/TG

Differential thermal analysis (DTA) with thermogravimetric analysis (TG) using STA Netzsch F3 Jupiter was carried out to determine the thermal stability and characteristic transformation temperatures of the materials studied. Measurements were performed in an argon atmosphere, in the temperature range from room temperature to 650°C at a heating rate of 10°C/min. Al2O3 crucibles were used for the measurements. The software bundled with the instrument was used to analyze characteristic temperatures. Figureure 4 shows the DTA/TG test stand.

Using DTA/TG studies, it was possible to determine the temperatures: the beginning of the mass loss (first onset) and, if possible, a significant decrease in mass (second onset); the end of the mass loss (end), as well as the maximum visible on the DTA signal corresponding to the phase transformation occurring in the polymer. In addition, the total mass loss was determined.

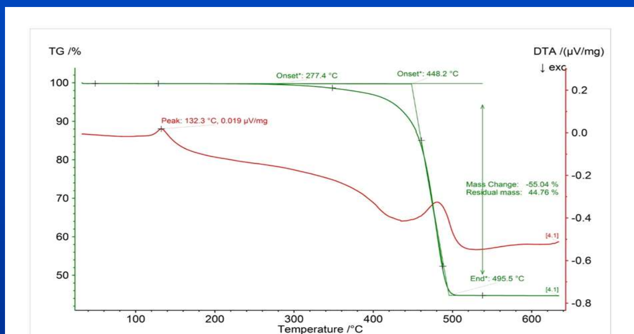

Figure 3: DTA/TG slice corresponding to the cross section of the entire gel cable.

From the tests for the entire cable, it can be observed that the overall mass proportion of polymers is about 55%. The cable itself consists of 3 different polymers, which is due to the different transformation temperatures observed on the DTA and degradation temperatures. In addition, the polymers from the black overall lagging and the colored copper lagging make up the bulk majority. The maximum temperature that the cable can be processed without changing the properties of the cable lagging polymers is about 105°C. For the petrogel itself, a transformation can be observed at 64.7°C, which is most likely related to the melting of the material.

Summary and discussion

Morphological studies of the cable have shown that it contains economically and environmentally important raw materials that should be fully recovered. The presented analysis of the currently used processing methods for gel cables highlights their incompatibility with the principles of the Circuit Economy. Basic research included differential thermogravimetric thermal analysis and viscosity tests. They show that the maximum temperature that can be processed on the cable is 105°C. Such a temperature acts behind the hydrophobic gel contained in the cables at the same time without changing the properties of the other raw materials.

Acknowledgements

The presented article is a stage of the work entitled: "Development of technology for recovery of raw materials from waste gel cables using thermal and physical-chemical processing methods in the context of the Circular Economy," carried out within the framework of the program "Implementation Doctorate V, edition 2021/2022" in cooperation with the Faculty of Environmental Engineering and Energy of the Silesian University of Technology in Gliwice. Co-funded by the research subsidy allocated for 2024 (08/030/BK_24/0131)