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Thermal Conductivity Properties of EVA, EEA and EBA

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Until recently, most studies on power cable's thermal phenomena and systematic properties for the quality improvement and lifetime enhancement of underground transmission power cable were limited to the XLPE insulator. However, this study, through the analysis of power cable's semiconducting layer materials in depth, tries to install a new recognition on the importance of semiconducting layer's roles and functions.

Since the usage purpose of the semiconducting layer differs from the interior to exterior of the XLPE insulator, the required property differs. Therefore, for the semiconducting layer to perform its necessary role in the power cable, it needs to have the adequate amount of carbon black, which gives the optimum thermal, electrical and mechanical properties. In this study, thermal properties are dealt with, especially thermal conductivity is focused [1, 2]. Therefore, through the measurements of thermal conductivity according to carbon black content and temperature, the best base resin will be assigned and the optimum carbon black content will be decided, while maintaining the given role as the semiconducting layer materials.

In this study, EVA (Ethylene Vinyl Acetate, Hyundai Petrochemical Co. Ltd.), EEA (Ethylene Ethyl Acrylate, ATOFINA) and EBA (Ethylene Butyl Acrylate, Mitsui Dupont) were used as the basic materials, and the content of conductive carbon black was the variable, and their content was 20, 30 and 40[wt%], respectively. The sheets were primarily kneaded in their pellet form material samples for 5 minutes on rollers ranging between 70[°C] and 100[°C]. Then they were produced as sheets after pressing for 20 minutes at 180[°C] with a pressure of 200[kg/cm]. The specimen used for measuring volume resistivity was 1[mm] thick sheet, 30[mm] wide and 64[mm] long.

Figure 1 shows the changes in thermal conductivity of the vinyl polymer according to carbon black content and temperature change. Before explaining Figure 1, thermal conductivity defines the extent of heat (=energy) transferred from one point to another within a certain object.

Generally polymers do not have the free electrons to transfer thermal energy from the point of high temperature to the low one. However, these polymers transfer their heat by the vibration of the atom. As the atom starts vibrating in one side, the heat is transferred as the nearby atoms start vibrating as the affect of the first one. This form is the phonon. As a reference, the materials used in this study are semiconducting complex materials which contain both polymers and conductive carbon black. As already mentioned, Figure 1 shows the change of thermal conductivity of the vinyl polymer according to the carbon black contents and temperature. As evident from Figure 1, thermal conductivity of the materials at 25[°C] increases in the range of 0.406~0.721[W/mK], and the materials at 55[°C] increases in the range of 0.469~0.807[W/mK]. Thus, thermal conductivity of the materials increases as the carbon black content increases or the temperature rises. This tendency can be explained by specific heat. Namely, specific heat is the thermal energy required to increase in 1[°C] with a 1g substance. This could be said as the particles within the material are storing the thermal energy [3~4].

The materials do not use all the heat they acquire for increasing the inner temperature of themselves. Thus, the particles within the material store the permitted thermal energy until the critical point (=the thermal equilibrium temperature within the material), and once it has been reached, they transfer the thermal energy to another point as they can not afford the energy. Thus, the semiconducting layer materials store the thermal energy from the continuous temperature rise until thermal equilibrium is reached, and transfer the left over heat to other points. In addition, as the content of carbon black, which has an excellent thermal conductivity, increases, and their distance between particles decreases. This promotes the movement of thermal electrons between carbon black particles, and the thermal vibrations of base resin atoms and carbon black thermal electrons increase. Therefore, it is obvious to say that the thermal conductivity increases as the carbon black content increases. From the results, EVA and EEA generally show similar curves, but at 25[°C], EVA has increased by 1.7~3.2[wt%] than EEA, and at 55[°C] EEA by 0.9~2.7[wt%]. Also, EBA shows more thermal conductivity than EVA and EEA. Therefore, EEA exhibits excellent thermal conductivity in general.

In this study, the thermal properties of vinyl polymer according to carbon black content and temperature have been measured. As the result, when measuring thermal conductivity, it increased as the carbon black content and temperature got higher.

This was because the particles within the materials stored the permitted thermal energy until a certain critical point (=thermal equilibrium temperature within the

materials), only transferring the thermal energy to other points when it could hold no more. Thus, the materials stored the thermal energy from the continuous temperature rise, and transferred the left over thermal energy to other points. From the results, EEA was an outstanding base resin with thermal conductivity among the materials.

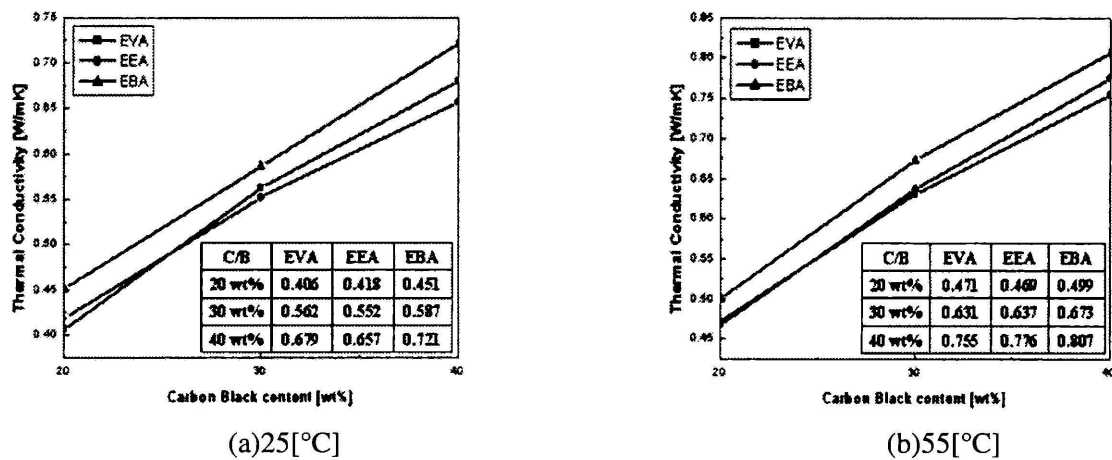


Fig.1 Thermal conductivity of vinyl polymer by carbon black content and temperature

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