VI International Conference Condensed Matter & Low Temperature Physics 2026

# Comprehensive analysis of low-temperature thermal conductivity of various epoxy resins and epoxy resin-based composites

**Yu. V. Horbatenko[1]**, A. I. Krivchikov[1], O. A. Korolyuk[1], V.V. Sagan[1], O. O. Romantsova[1,2]

*[1]B. Verkin Institute for Low Temperature Physics and Engineering of NAS of Ukraine, Kharkiv, 61103, Ukraine*
*[2]Institute for Low Temperatures and Structure Research, Polish Academy of Sciences, 50-422 Wroclaw, Poland*
*horbatenko@ilt.kharkov.ua*

**Abstract:** We have processed a significant amount of literature data on low-temperature thermal conductivity data of various epoxy resins in the temperature range from 1 K to 100 K: they demonstrate the so-called glassy behavior of thermal conductivity, which can be represented as the sum of two terms:

$$\kappa(T) = \kappa_{pl}(T) + \kappa_0 \cdot \exp(-E/T), \qquad (1)$$

where the first term is the thermal conductivity plateau, $\kappa_{pl}$., which occurs in disordered solids in the range 2-10 K; and the second term describes a smooth gradual increase in thermal conductivity - and it is similar to the Arrhenius expression, which, in turn, has two fitting parameters – pre-exponential factor and some characteristic energy[1].

It should be noted that the representation of κ(T) data as a sum of two terms is consistent with the "Unified theory of thermal transport in crystals and glasses" proposed by Simoncelli- Marzari-Mauri [2], and manifested that heat transfer in a solid is realized in two ways: particle-like (first term) and wave-like tunneling (second term) –
$\kappa(T) = \kappa_p(T) + \kappa_c(T)$.

At low temperatures, the particle-like contribution κp in amorphous polymers is described using a Matthiessen-type relation [3]:

$$1/\kappa_p = 1/\kappa_{TLS} + 1/\kappa_{pl} \qquad (2)$$

**$\kappa_{TLS}$ represents resonant scattering by two-level system (TLS), following a power law: $\kappa_{TLS} = \beta T^n$ with $n \approx 2$: so thermal conductivity data for the low-temperature range of epoxy resins (to the left of the plateau) demonstrate a dependence of *κ(T)* close to $T^2$**

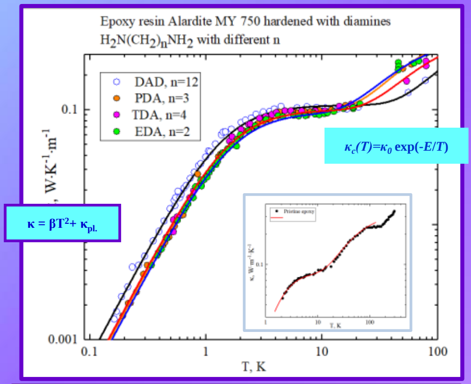


**Fig. 1.** Temperature dependences of thermal conductivity of Epoxy resin Alardite MY 750 hardened with diamines $H_2N(CH_2)_nNH_2$ with different n (C. I. Nicholls and H.M.Rosenberg, *J. Phys. C: Solid State Phys*. **17** 1165, 1984). **Inset:** pure epoxy resin (Nataj Z., Nature Communications **14**.1, 3190, 2023).

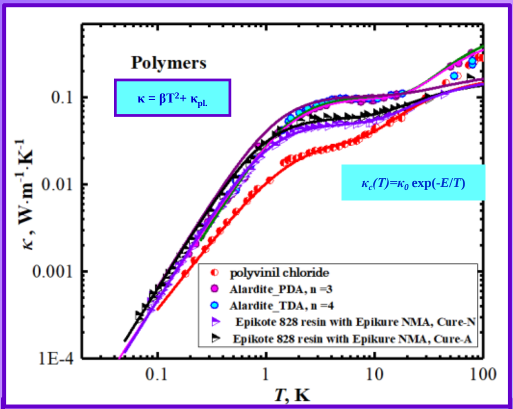


**Fig. 2.** Thermal conductivity analysis of low-temperature data for some polymer materials. Solid lines present approximation according to Expr. (2).

$$\kappa(T) = \kappa_p(T) + \kappa_c(T) = \frac{\beta T^n \cdot \kappa_{pl}}{\beta T^n + \kappa_{pl}} + \kappa_0 \cdot \exp(-E/T) \qquad (3)$$

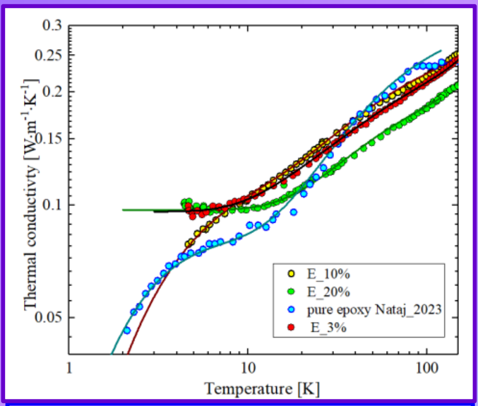


**Fig. 3.** Temperature dependences of thermal conductivity of pure epoxy and epoxy-GO composites. Solid lines present approximation according to Expr. (3).

## Conclusions:

We have analyzed low-temperature thermal conductivity data for some epoxy resins and epoxy resin-based composites in the temperature range 0.1-100K. They demonstrate glass-like behavior of κ(T) – it consists of two terms: the first is proportional to $T^2$, and the second is exponential.

All fitting parameters have been obtained.

**Acknowledgment:** The work supported by the Research Project for Young Scientists of the National Academy of Sciences of Ukraine **No. 0125U002900: 12/04-2026**

## References:

[1] Y.V.Horbatenko, V.V.Sagan, O.A.Korolyuk, O.O.Romantsova & A.I.Krivchikov, Low Temp. Phys. **50**(5), 379-388 (2024).

[2] M. Simoncelli, N. Marzari, and F. Mauri, Nature Physics, **15**, 809 (2019).

[3] Y.V. Horbatenko, O.A. Korolyuk, A.I. Krivchikov & M.S. Barabashko, Low Temp. Phys. **52**(4), 418-426 (2026).