Thermax® in Polystyrene Foam

Polystyrene (PS) foam is known for its insulation and damping properties which has made it a popular choice for insulation panels and packaging materials. It can be processed either by expansion (EPS) or extrusion (XPS). It is well established that the inclusion of carbon additives such as graphite and carbon black can improve the insulation performance of thermoplastic foams. The carbon acts as an infrared radiation absorber lowering the thermal conductivity of the foam. In this study, the effects of adding Thermax® thermal carbon black to the PS foam were investigated. Relative to other carbon blacks, thermal carbon black has low structure and large particle size which can provide cleanliness and processing advantages.

The benefits of Thermax® thermal carbon black found in this study include:

- Excellent dispersion as observed by scanning electron microscopy (SEM)
- Good processing characteristics according to laboratory technicians and researchers
- Similar expansion, density, open-cell content, and compression properties as the control
- ~3% reduction in thermal conductivity and ~14% reduction in thermal effusivity[1]

The PS formulations can be found in Table 1. Recycled PS (rPS) was used as a more sustainable option given the well documented environmental impact of virgin PS. A masterbatch was produced with rPS and 20 wt.% Thermax®. This was let down to achieve 2 wt.% and 4 wt.% Thermax® in the rPS foam. The foam morphology was observed using scanning electron microscopy (SEM). Foam densities, open-cell content, compression behavior, and thermal insulation performance were also evaluated. Both thermal conductivity and thermal effusivity were measured. The processing and testing were completed at National Research Council (NRC) of Canada in Boucherville, Quebec.

Table 1. Polystyrene formulations

Ingredient	Control	A	B
Vystyrene (recycled PS), kg/hr	20	18	16
Masterbatch (rPS/20 wt.% Thermax®), kg/hr	0	2	4
CO_2, wt.%	4.5	4.5	4.5

[1] Thermal conductivity is a measure of a material's ability to conduct heat. Thermal effusivity is calculated as the square root of the product of thermal conductivity and volumetric heat capacity and is a measure of a material's ability to exchange heat with its immediate surroundings at a surface.

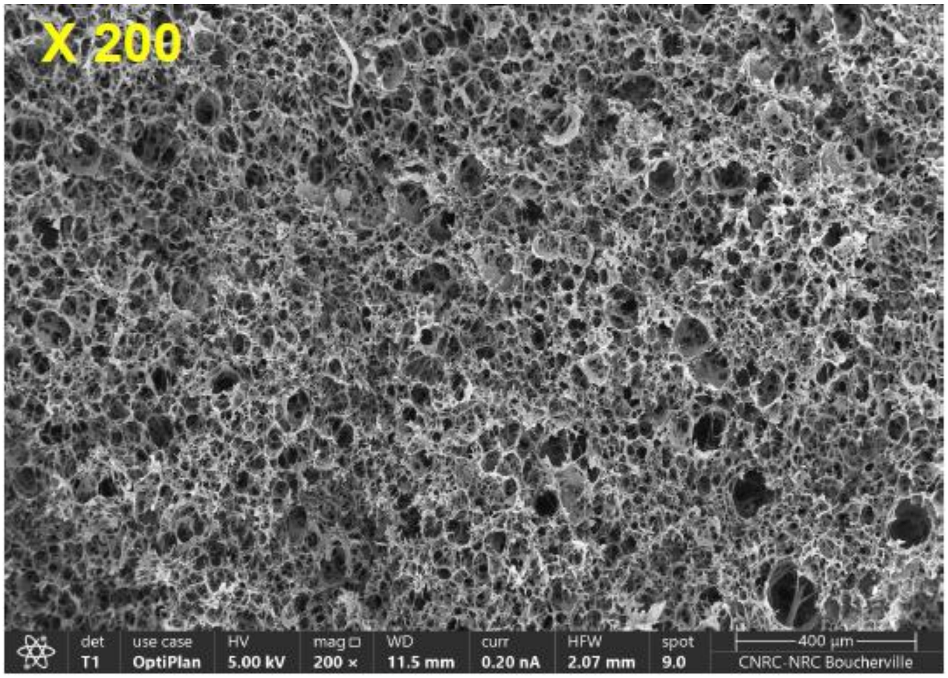

Figure 1. SEM image of rPS foam with 4 wt.% thermal black.

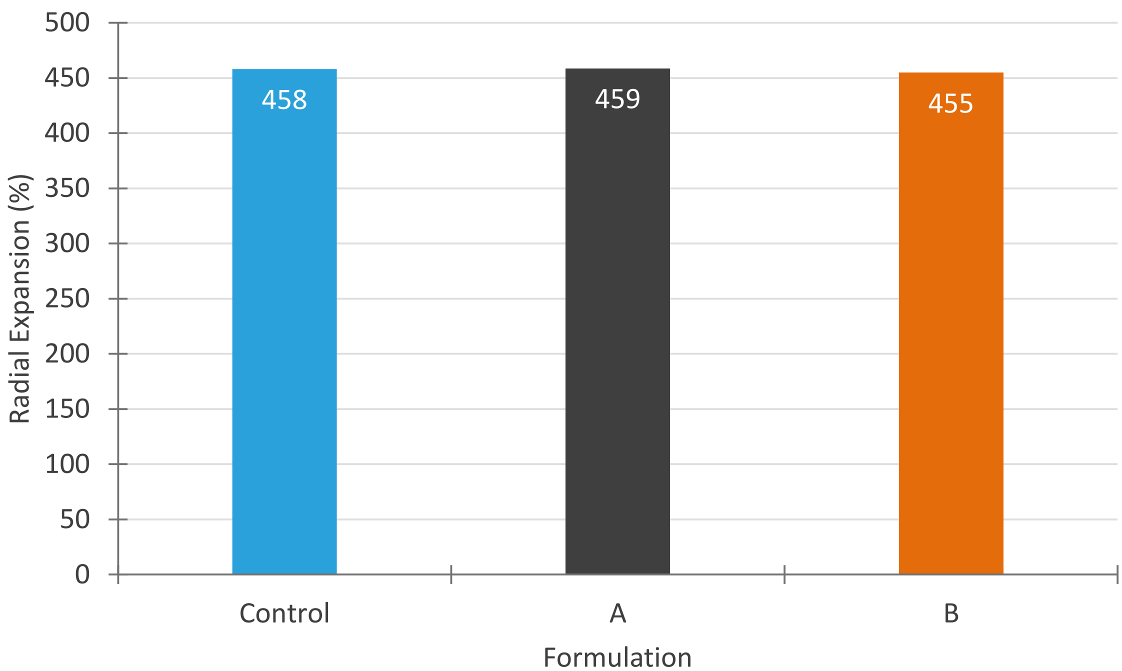

Figure 2. Radial expansion of the rPS foams. All foams had similar expansion values.

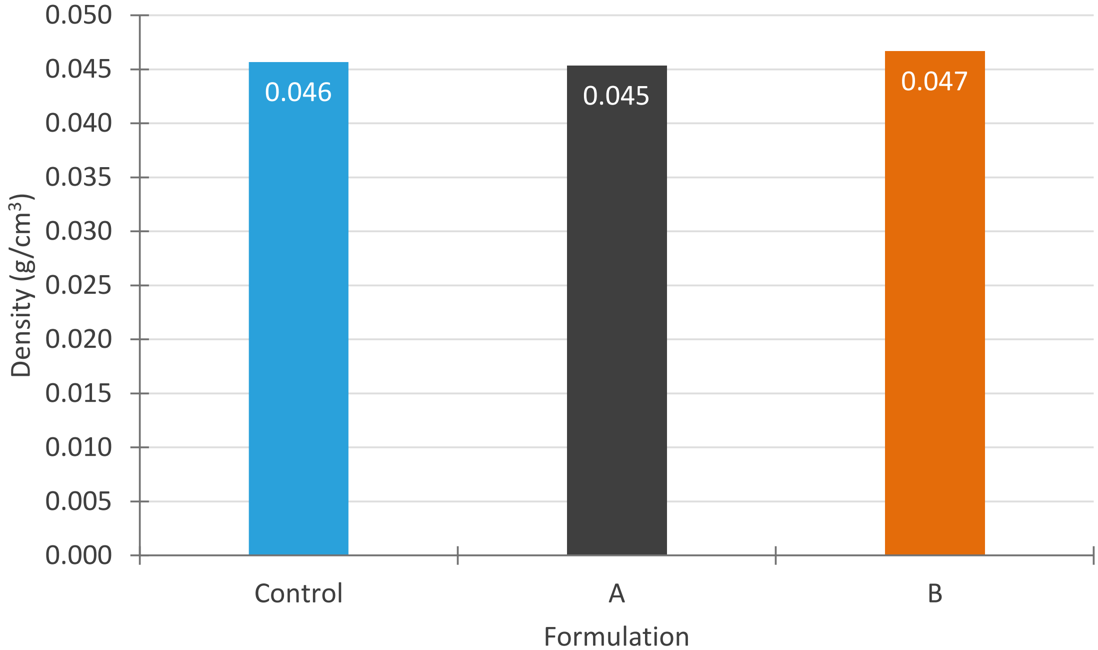

Figure 3. Density of the rPS foams. All foams had similar densities.

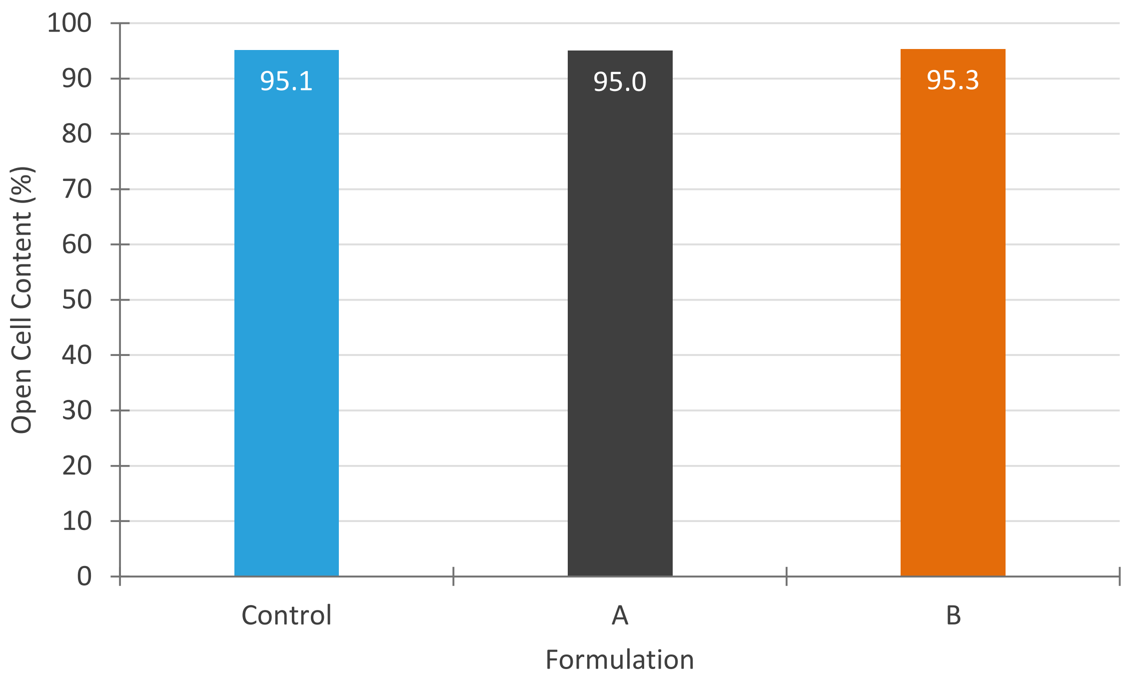

Figure 4. Open cell content of the rPS foams. All foams had similar open cell content and would be classified as open-cell foams.

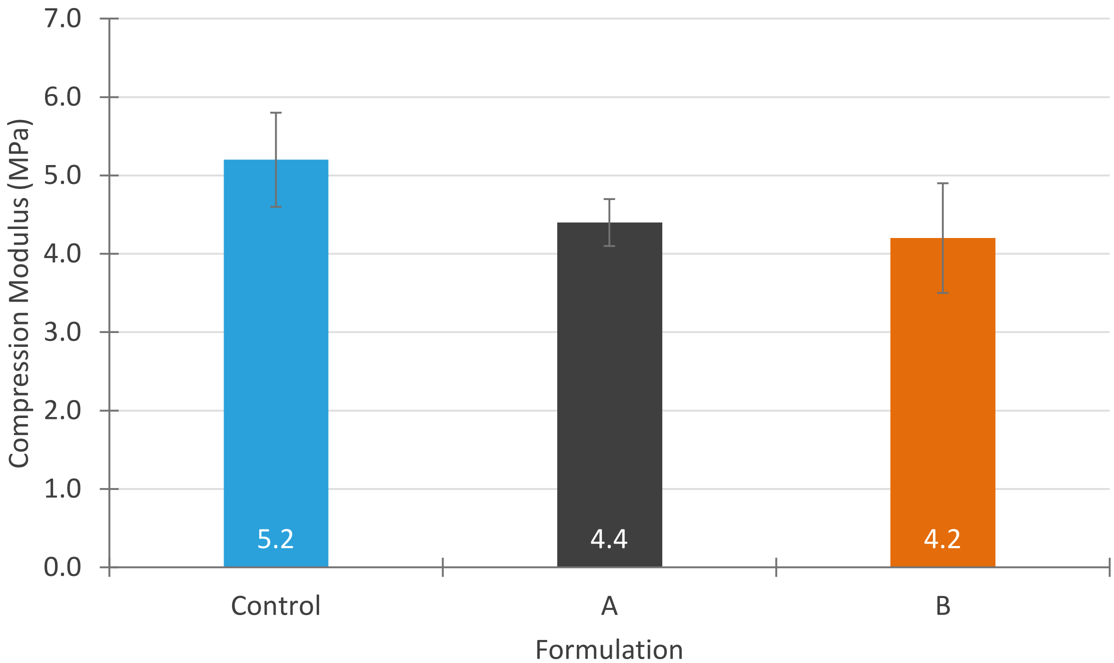

Figure 5. Compression modulus of the rPS foams. Compression modulus decreased slightly as thermal black content increased.

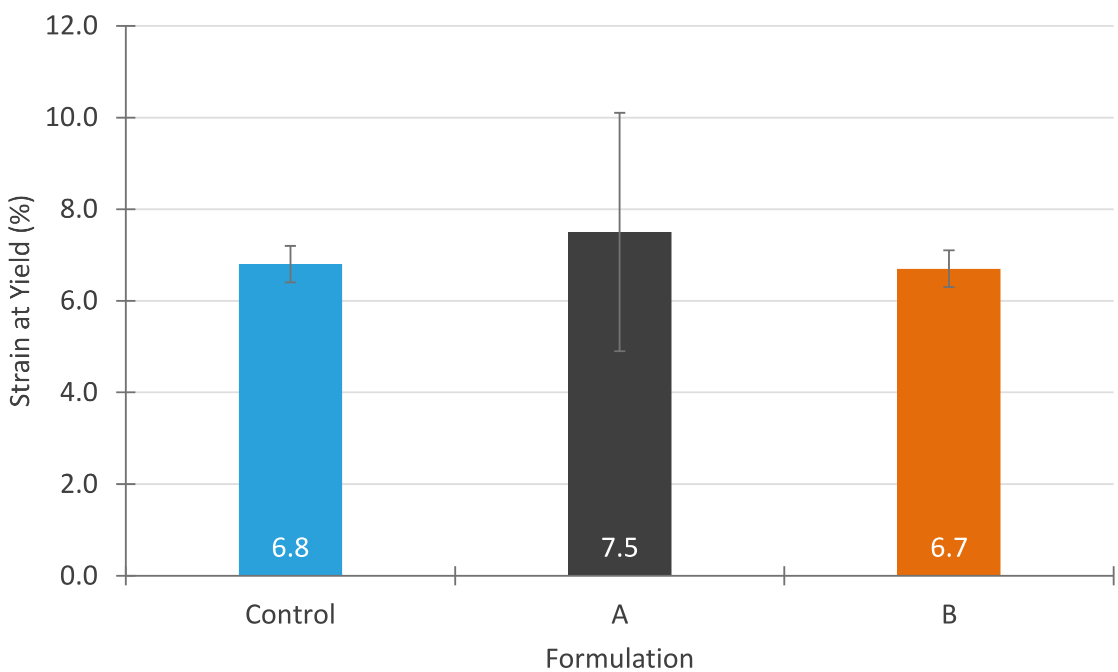

Figure 6. Strain at yield of the rPS foams. There were no significant differences in yield strain.

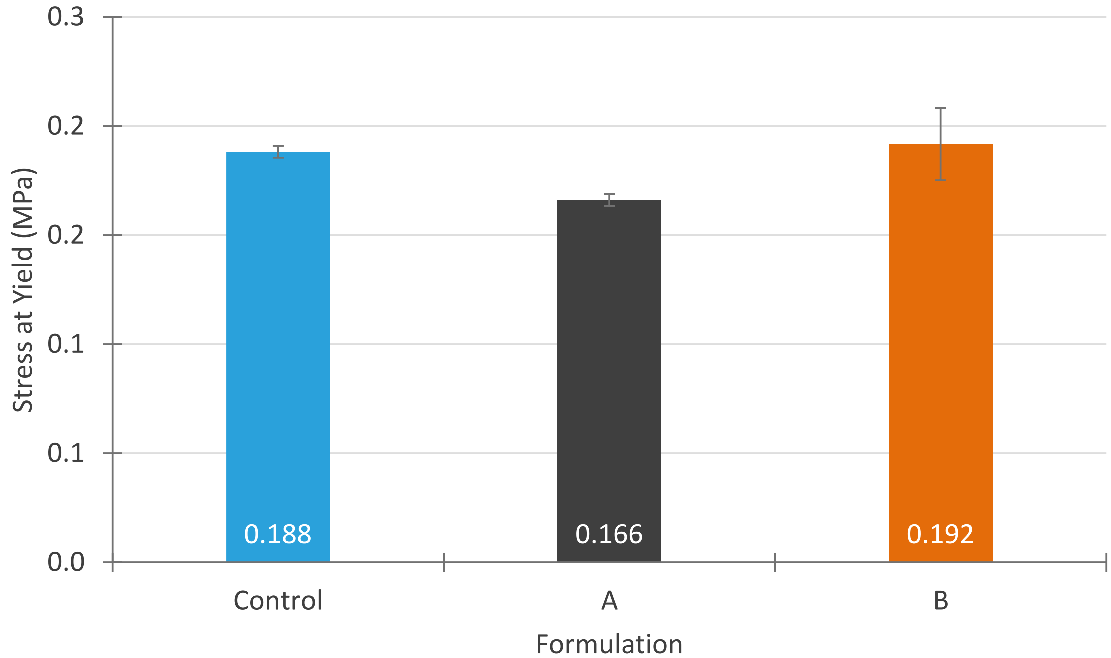

Figure 7. Stress at yield of the rPS foams. The foam with 2 wt.% thermal black had slightly lower yield stress than the other foams.

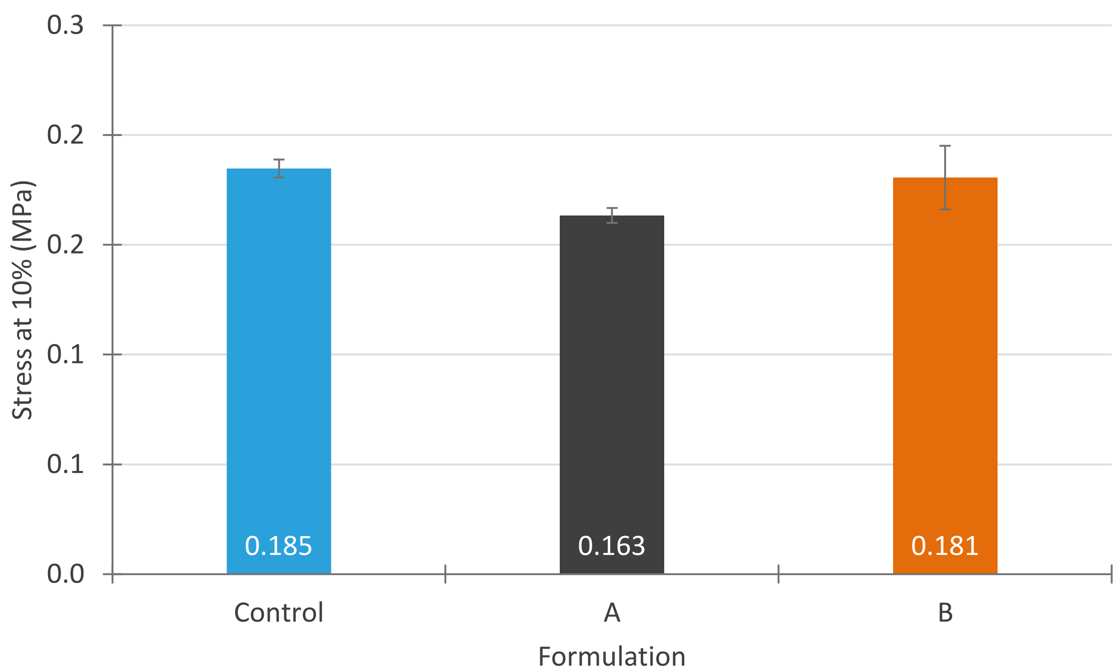

Figure 8. Stress at 10% strain of the rPS foams. The foam with 2 wt.% thermal black had slightly lower values than the other foams.

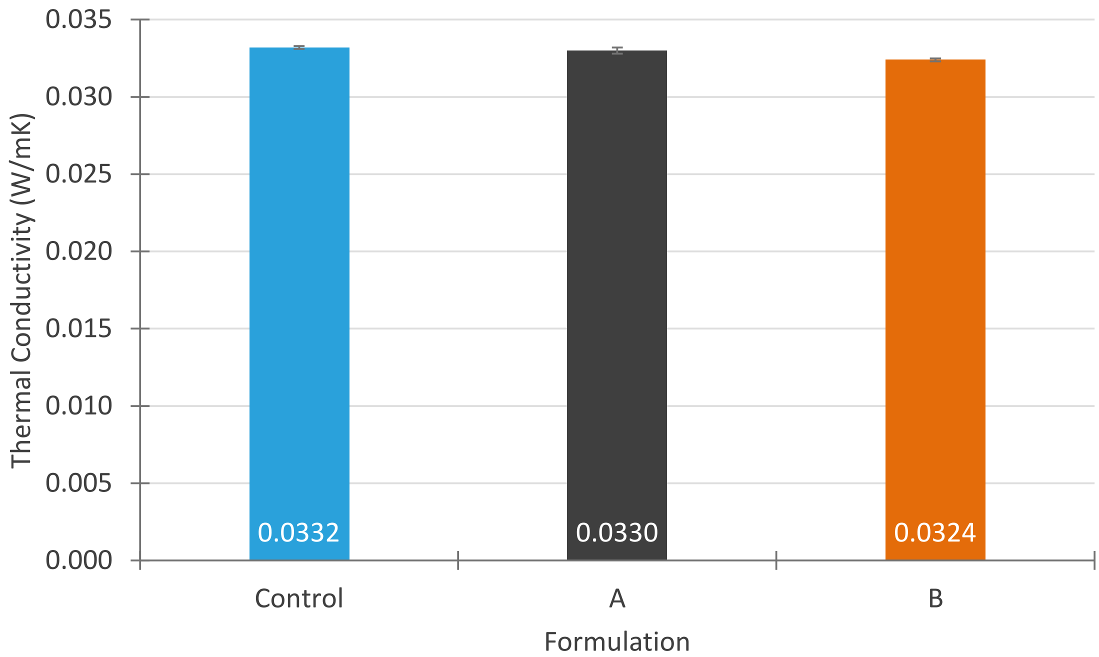

Figure 9. Thermal conductivity of the rPS foams. Thermal conductivity was reduced by ~3% for the sample with 4 wt.% thermal black.

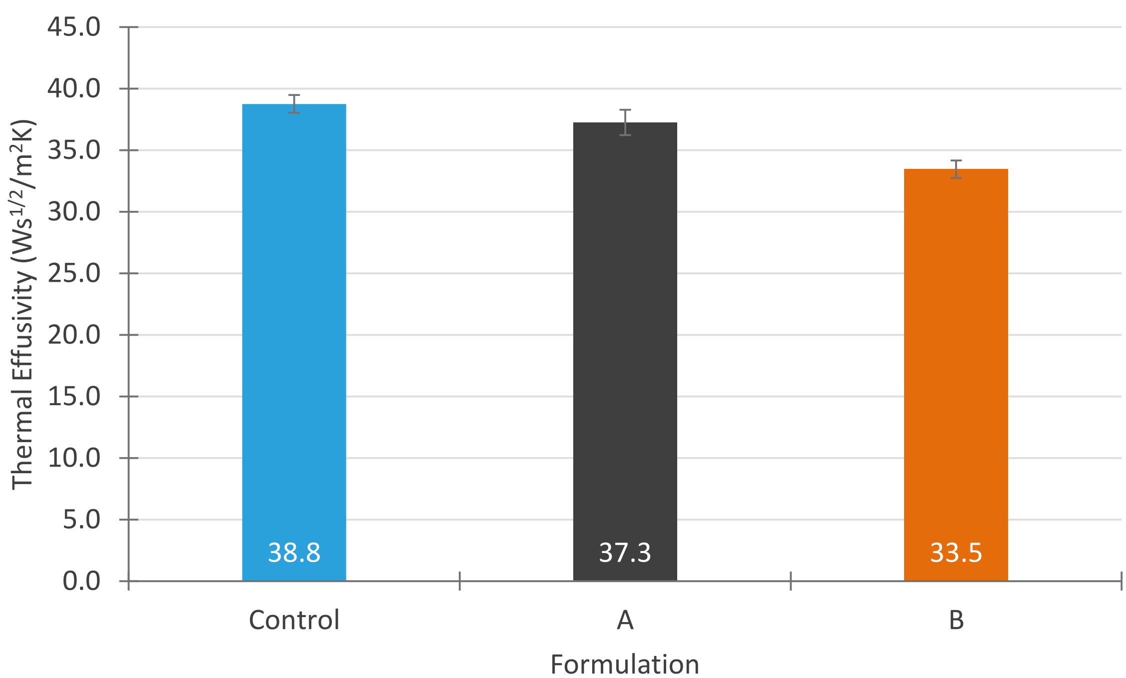

Figure 10. Thermal effusivity of the rPS foams. Thermal effusivity was reduced by ~14% for the sample with 4 wt.% thermal black.