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Recycled rubber-silica aerogels for thermal insulation of buildings

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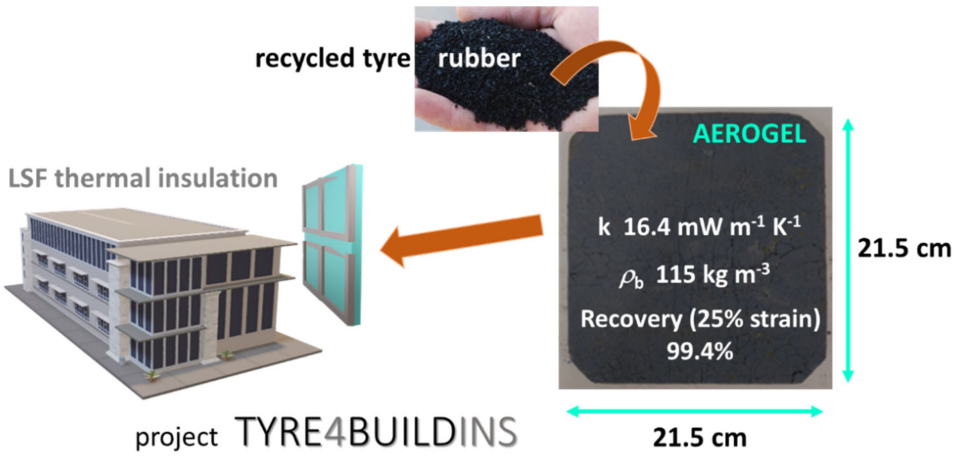
GRAPHICAL ABSTRACT



ABSTRACT

It is well known that buildings contribute to a large amount of the total primary energy consumption in Europe – 30-40%, due to cooling, heating and lighting energy demands [1]. This level of consumption can be greatly reduced by using superinsulator materials. Even if their price is not competitive with other common construction insulation materials (*e.g.* mineral wool), they can contribute to the effective reduction of the energy losses in targeted elements of the building, with limited areas but main contributors to these losses. Metal frames in Lightweight Steel-Framed (LSF) construction systems (increasing trend), windows and doors are representative examples, which favour thermal bridges arising from metal high thermal conductivity, thus penalizing significantly the efficiency of the overall thermal insulation envelope. The thermal bridges may be responsible for up to 30% of heat losses in buildings. On the other hand, many waste materials produced worldwide must be recycled in

a way to avoid environmental issues and guaranteeing the sustainability of the Planet. From these wastes, tyre rubber is of major concern, and it has already been integrated in some civil engineering.

Silica aerogels are recognized as one of the most promising superinsulation materials for a multitude of applications. In this work we successfully designed, synthesized and characterized recycled rubber-silica aerogels reinforced with fibres of several types (polyester, silica, recycled tyre fibres), aiming at gathering all those energy and environmental needs [2], and in line with circular economy principles. A rubber sol prepared from rubber crumbs was prepared and easily mixed with the silica sol. The gels were subject to a silylation step to follow the Ambient Pressure Drying route. No shrinkage was observed in the samples and their microstructure was not affected by the presence of the rubber sol phase.

The final composites exhibited a thermal conductivity in the range 16-28 mW m^{-1} K^{-1} and densities between 100 and 200 kg m^{-3}, depending on the type of reinforcement fibres [2]. In addition, the samples showed very good thermal stability (negligible weight loss up to 400 ^{o}C) and remarkable flexibility under cyclic compression loads (recoveries above 96%) [2]. They displayed hydrophobic behaviour, with contact angles between 125º and 138º. The dynamic stiffness of the composite including polyester fibres was 11 $MN.m^{-3}$, which is a very low value when compared, for instance, with recycled tyre rubber and cork/rubber composites, also showing a promising acoustic insulating behaviour. The properties of these new aerogel composites fit the needs for the target insulation of metal frames in buildings, allowing to avoid the deleterious effect of thermal bridges and, consequently, reducing significantly the energy losses, while contributing to solve the environmental problem of tyre rubber wastes.

ACKNOWLEDGEMENTS

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