

**Part VI**  
**Open**

## Chapter 44

# Eco-friendly and Biocompatible Materials for Noise Reduction in Healthcare Environments

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### Abstract

Noise pollution has been shown to negatively affect the lives of millions of people, resulting in problems such as stress, high blood pressure, hearing loss, and sleep disruption. This issue is of great importance in healthcare spaces, where not only low noise levels are preferable but also a low-toxicity environment is needed. In this context, conceiving innovative solutions that help reduce noise while preserving safety conditions for clinical activity has become a priority among medical industry professionals and the scientific community. Our research proposes an eco-friendly, biocompatible material made from recycled plastic bottles to reduce noise pollution and enhance acoustic comfort in healthcare environments. While plastic production increases significantly every year, its very low recycling rate leads to large amounts of it entering the environment, thus urging the pursuit of sustainable solutions that allow for the reuse of plastic waste. Therefore, by transforming this plastic into PET (polyethylene terephthalate) felt composites, the health risks associated with noise and the environmental challenge are both addressed. Prototype samples were manufactured by an industrial partner and successfully tested in a childcare playroom of the Paediatric Oncology Department of the Hospital Universitario La Paz, in Spain. In doing so, not only was significant noise reduction achieved, but also a positive impact on the well-being of hospitalized children, while also contributing to better preservation of the planet. Preliminary results show the potential of the developed material and encourage us to extend this product to healthcare institutions worldwide.

**Keywords:** *Eco-friendly Material, Biocompatible Material, Noise Reduction*

### Introduction

Reducing the noise pollution has become a priority in a society increasingly aware of its harmful effects on human health<sup>1</sup>. Many studies have shown the importance of creating more comfortable and noiseless spaces for our well-being, especially in the case of healthcare environments such as hospitals<sup>2</sup>. In this context, the development of new noise-reducing materials plays a vital role not only to help lower stress and rest disruption but also to guarantee a safe and low-toxicity environment. In fact, the increasing

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<sup>1</sup>World Health Organization, Burden of Disease from Environmental Noise. Quantification of Healthy Life Years Lost in Europe (WHO Regional Office for Europe, 2011).

<sup>2</sup>Denise B. Choiniere, "The Effects of Hospital Noise," *Nursing Administration Quarterly* 34, no. 4 (2010): 327–33, <https://doi.org/10.1097/NAQ.0b013e3181f563db>.

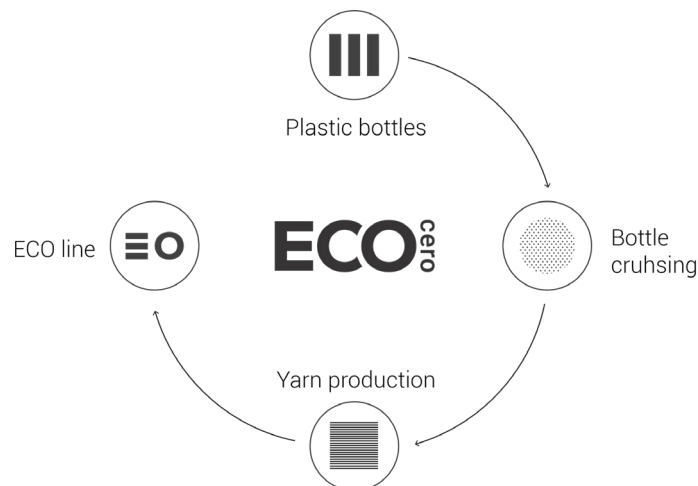
demand for this type of product in multiple healthcare projects urges the need to foster collaboration between diverse professionals and organizations.

On the other hand, environmental concerns such as climate change, pollution, and biodiversity loss have increased attention towards the development of production processes to be more respectful for the environment. In this regard, one of the main sources of product waste nowadays is linked to the industry of plastic manufacturing, whose environmental commitment with its collection and recycling has become a priority that aligns with the circular economy principles. While some recent works have shown the potential of prefabricated panels with recycled thermoplastic PET (polyethylene terephthalate) materials<sup>3</sup>, low-toxicity and biocompatibility were not assessed, thus compromising their safe applicability in healthcare scenarios.

This research is dedicated to the development and analysis of sustainable sound-absorbing acoustic panels made from recycled plastic bottles for their use in healthcare environments, thus combining acoustic comfort with health safety<sup>4</sup>.

## Eco-friendly and Biocompatible Material

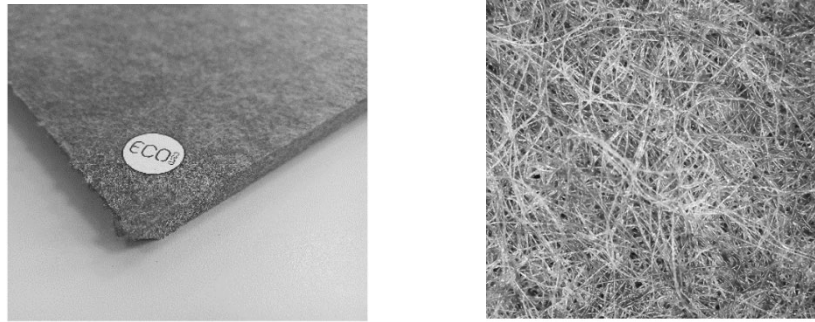
The eco-friendly and biocompatible material developed consists of acoustic panels made from PET, a plastic widely used in the production of beverage bottles. With more than 5 million bottles recycled last year (up to 75 plastic bottles are recycled to make 1 m<sup>2</sup> of product), these PET acoustic panels contribute to reducing the amount of plastic waste in the environment while promoting the circular economy. The fabrication procedure is summarised in Figure 1. In brief, the plastic bottles are collected, separated, cleaned, and crushed into small flakes that, after undergoing a heating and extrusion process, produce fine and malleable yarn fibres that can be compacted to form an insulating panel as depicted in Figure 2.



**Figure 1:** Fabrication process of ECOcero sound-absorbing PET panels (Source: ECOcero <https://ecocero.com/en/>).

<sup>3</sup>Silvia Cavagnoli et al., “Advancing Sustainable Construction Through Comprehensive Analysis of Thermal, Acoustic, and Environmental Properties in Prefabricated Panels with Recycled PET Materials,” *Energy Build.*, 312 (2024): 114218, <https://doi.org/10.1016/j.enbuild.2024.114218>.

<sup>4</sup>David del Rosario-Gilbert et al., “Eco-friendly and Biocompatible Material to Reduce Noise Pollution and Improve Acoustic Comfort in Healthcare Environments,” *Buildings* 14, no. 10 (2024): 3151, <https://doi.org/10.3390/buildings14103151>.



**Figure 2:** Eco-friendly PET panel: (Left) sample of the fabricated material and (Right) microstructure image obtained by SEM (Scanning Electron Microscope).

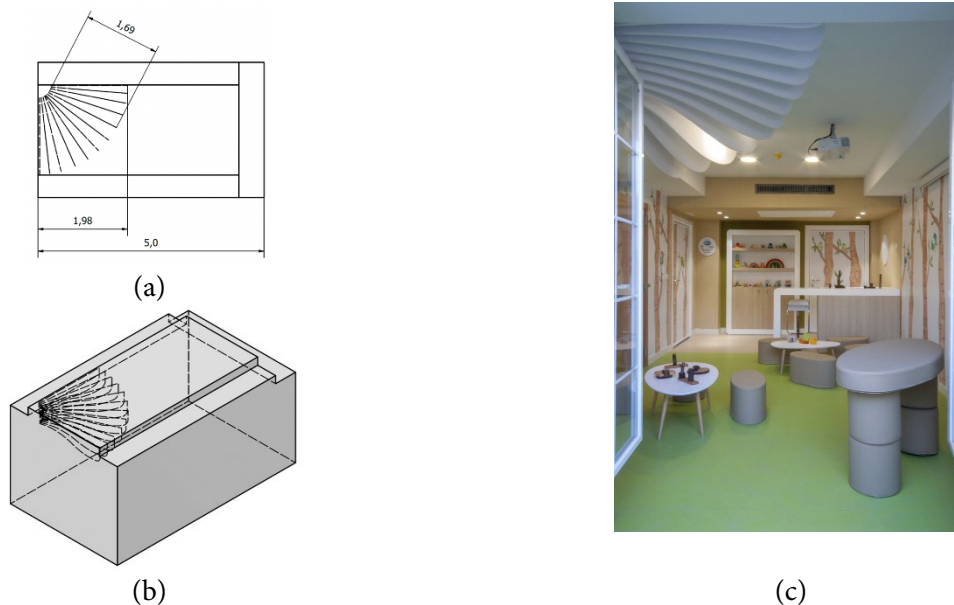
First, both the sound absorption and thermal performance of the fabricated panels were assessed following the standardized procedures described in ISO 11654 (ISO 11654) and BSEN12667:2001 (BSEN12667:2001), respectively, the results showing that these guarantee both an excellent acoustic and thermal comfort, with weighed sound absorption coefficients of 0.95 (class A) for a plenum arrangement, thermal conductivity values below 0.04 W/mK, and thermal resistance above 0.6 m<sup>2</sup>K/W, thus providing an excellent thermos-acoustic insulation.

In addition to its excellent thermos-acoustic properties, the resulting panel is resistant to fire, moisture, and microorganisms. Another key feature is that the panels are VOC certified, as assessed according to ISO 16000-6 (ISO 16000-6), so there is no need to worry about volatile organic compound emissions into the air, which is of great importance for guaranteeing air quality for its use in healthcare spaces. As for the maintenance, given that the PET material does not accumulate any type of fungus or bacteria (assessed following the procedure described in the ASTM G21-15 (ASTM G21-15)), it becomes much more occasional and can be reduced to dust or stain removal using conventional feather dusters/vacuum or alcohol-based cleaners, respectively. Finally, to extend the use of these panels to green buildings, more than 20 international certifications (LEED, BREEAM, etc.) were also accredited. To sum up, the proposed solution was not only shown to be comparable to conventional insulation systems used in buildings both in terms of thermal and acoustic performance (class A), but also yields antifungal properties and low VOC emission, which makes it suitable for its adoption in a broad range of healthcare environments, as it will be shown next.

## Case Study: Childcare Room

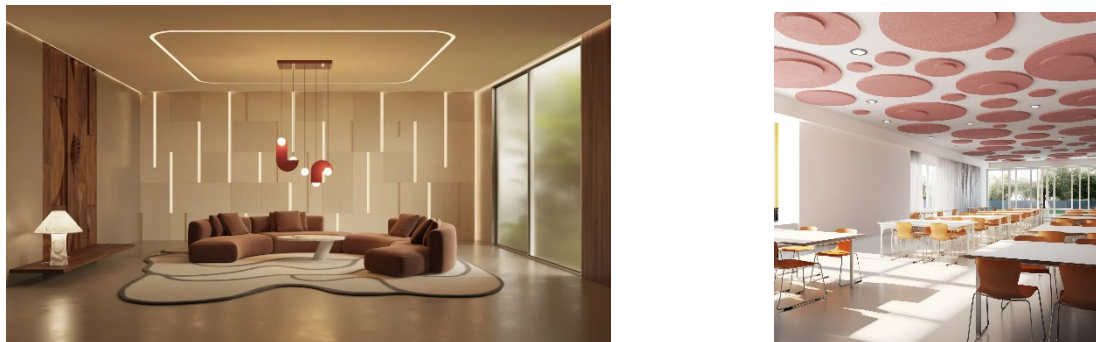
One of the first actions was to set up a paediatric ward at the Hospital Universitario La Paz, one of the major hospitals in Spain. Specifically, the case study consisted of a childcare playroom in the Department of Paediatric Oncology, whose plan view, rendered view, and general view are depicted in Figure 3. Several layers of PET panels were installed perpendicular to the indoor ceiling using easy mounting glue, the acoustic treatment showing a 90% reduction in the average reverberation time values and a significant increase in the speech intelligibility parameters<sup>5</sup>.

<sup>5</sup>David del Rosario-Gilabert et al., “Eco-friendly and Biocompatible Material.”



**Figure 3:** Case study of eco-friendly PET panels in a childcare playroom at the Hospital Universitario la Paz (Spain): (a) plan view, (b) rendered view, and (c) general view.

On the other hand, the design capabilities for sizing, shaping, and colouring make it very versatile and applicable to additional spaces such as reception halls or dining rooms (see some examples in Figure 4). In fact, the robust installation design features of these panels (e.g., tongue and groove) yield high durability and therefore a long service life while still being aesthetically attractive compared to conventional ones in terms of appearance.



**Figure 4:** Application of sound-absorbing PET panels in other scenarios: hall (left) and dining room (right).

## Conclusions and Ongoing Research

In summary, the recycled and biocompatible acoustic material developed presents excellent features for its application in healthcare environments, including:

- Excellent sound absorption performance (class A).
- High thermal resistance and low thermal conductivity.
- Antifungal and moisture resistance.
- Low VOC emissions.
- Long-term durability.
- Aesthetic design capabilities.

In addition to the above features, it also shows promising perspectives for additional purposes in healthcare scenarios such as Intensive Care Units<sup>6</sup> or incubators for cell dynamic viability assessment<sup>7</sup>, which constitute some of the ongoing research lines.

## Acknowledgements

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<sup>6</sup>Jeanette Vreman et al., “The Effectiveness of the Interventions to Reduce Sound Levels in the ICU: A Systematic Review,” *Critical Care Explorations* 5, no. 4 (2023): e0885. <https://pubmed.ncbi.nlm.nih.gov/36998528/>.

<sup>7</sup>David del Rosario-Gilabert et al., “Eco-friendly and Biocompatible Material.”

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