Applied Acoustics 85 (2014) 150–160

Contents lists available at ScienceDirect

Applied Acoustics

journal homepage: www.elsevier.com/locate/apacoust

Review

# Manufacturing and modelling of sintered micro-porous absorption material for low frequency applications

Marjaana Karhu [a,*], Tomi Lindroos [a], Seppo Uosukainen [b]

[a] VTT Technical Research Centre of Finland, Sinitaival 6, P.O. Box 1300, FI-33101 Tampere, Finland
[b] VTT Technical Research Centre of Finland, Tekniikantie 4A, P.O. Box 1000, FI-02044 VTT, Finland

ARTICLE INFO

Article history:
Received 11 December 2013
Received in revised form 13 March 2014
Accepted 10 April 2014
Available online 21 May 2014

Keywords:
Micro-porous
Sound absorption

ABSTRACT

A novel sintering based method to produce thin ultrahigh molecular weight polyethylene, UHMWPE, absorption material layer to increase absorption at low frequencies is introduced. The experimental impedance tube measurement results show that a 4 mm thick sintered sample layer increases absorption at a low frequency range below 1000 Hz compared with commercial melamine and polyester absorption foam samples. To cover a wider frequency range, multilayer structures composed of a sintered micro-porous material layer and commercial melamine and polyester foam layers are created and examined. The sintered sample layer also increases absorption in multilayer structures at low frequencies. Absorption coefficient values above 0.5 are reached starting from 200 Hz with multilayer structures. Software exploiting Biot's theory of porous materials has been adopted to fit the experimental absorption data for sintered samples, commercial foams and multilayers. Software based on Biot's theory was found to deliver quite good correlation with measured absorption coefficient values, with disagreements below 10% between the measured and estimated values.



**Contents**



* Corresponding author. Tel.: +358 20 722 3676; fax: +358 20 7223498.
E-mail address: marjaana.karhu@vtt.fi (M. Karhu).

http://dx.doi.org/10.1016/j.apacoust.2014.04.008

## 1. Introduction

There is strong demand for thin, lightweight and low-cost sound-absorbing materials in a wider frequency range, especially covering low frequencies. Low frequencies are problematic for traditional sound absorption materials because good absorption requires high thicknesses of the material. The research on acoustic absorption materials has mainly been on developing structures from existing materials and modelling traditional commercial absorption materials [1–4]. The sound absorption of these materials is typically high in high-frequency regions but, because of the low capacity of sound energy attenuation, the sound absorption is poor at low frequencies of several hundred Hertz. However, there have been attempts to develop completely new absorption materials. The most promising results have been achieved with micro-porous polymers, structures with dual or graded porosity [5,6]. Zhou et al. [7–10] reported that polymeric micro-spheres and micro-particles have good sound absorption capability, especially in the low frequency region. In study [8], composite material consisting of enclosed polymer micro-particles in polyurethane (PU) foam shows higher sound absorption in the low frequency region than pure PU foam with the same thickness. Study [9] looks at the properties of three polymeric micro-particle layers. Structures with a total thickness of 30 mm, consisting of a first matching layer of polystyrene particles (PS), a second matching layer of polypropylene particles (PP) and a rubber granulate layer as the sound attenuation layer, show excellent sound absorption properties for a wide frequency range. The problem is the practical use of loose particles. Swift et al. [11,12] compared loose and consolidated rubber granular mixes and pointed out that the overall absorption is reduced by the consolidation. Conducted studies indicate the possibilities of micro-particles for low frequency applications. Still there is lack of experience of consolidation techniques for producing micro-porous materials from micro-particles to be utilized in sound absorption applications.

Studies about sintering involved processing routes to produce porous polyethylene materials are presented [13,14]. Webber et al. [15] reported using the sintering and extrusion conditions for the production of micro-porous, auxetic form UHMWPE when typically micro-porous auxetic form UHMWPE is manufactured by employing powder processing techniques including compaction, sintering and extrusion. Sintering UHMWPE particles to produce micro-porous material layer for increasing absorption at low-frequency range has not been reported previously. In this study, the novel sintering-based manufacturing route is introduced to produce thin micro-porous UHMWPE based sound absorption material layer to increase absorption in the low frequency range. To optimize the absorption characteristics in a wider frequency range, multilayer structures composed of a sintered micro-porous material layer and commercial melamine (MEL) and polyester (SD) foam layers are created and examined. Software (ESI Group NOVA) utilizing a mathematical model according to Biot's theory [16,17] for porous materials has been adopted to fit the experimental absorption data for sintered UHMWPE-based samples, commercial absorption foams and multilayers based on sintered sample layers and foam layers.

## 2. Experimental procedures

In this study, two types of UHMWPE powder were used to produce micro-porous sintered samples: GUR 2122-5 powder supplied by Ticona and HE 1878 powder supplied by Borealis. Microstructures of the starting powders have been examined with Scanning Electron Microscopy (SEM) and presented in Figs. 1 and 2. SEM micrographs reveal that the particle size of GUR 2122-5 powder (in Fig. 1) is much smaller than of HE 1878 (in Fig. 2) powder. Differences in powder morphologies are also detected.

### 2.1. Sample manufacturing and microstructure studies

A hot air sintering mould was specially designed and prepared for manufacturing sintered samples. At the first manufacturing stage, the starting UHMWPE powder was placed in the mould, which was pretreated to decrease sticking of the sample during sintering. In the second stage, the mould was placed in the oven

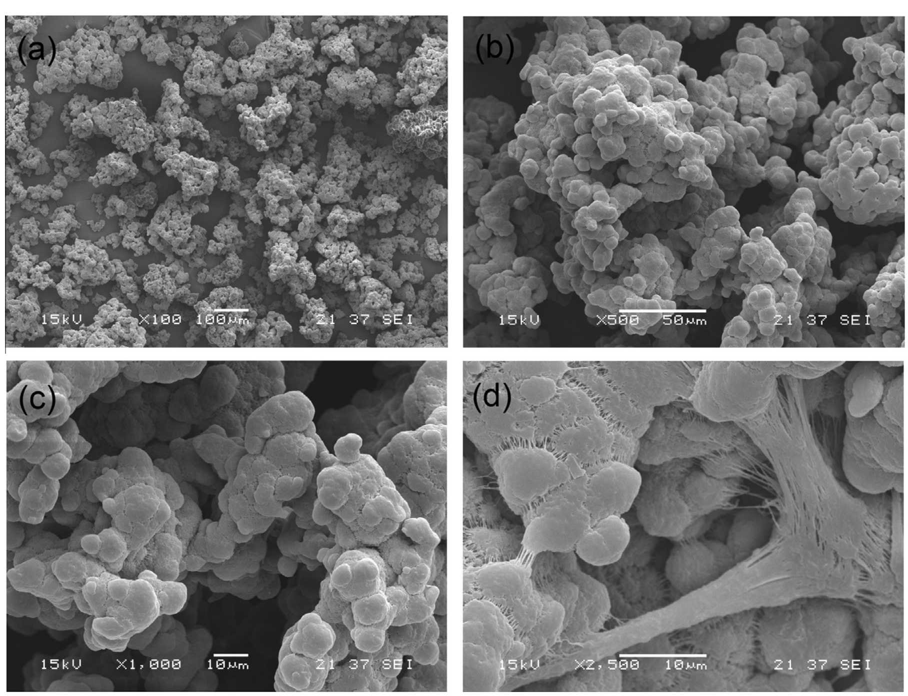


**Fig. 1.** SEM micrographs of Ticona GUR 2122-5 powder with magnifications: (a) 100×, (b) 500×, (c) 1000× and (d) 2500×.