Application Note RACCT9001

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Earplug Pore Size Analysis by X-ray CT

About the sample: Roll-down foam earplugs

Roll-down foam earplugs are one of the most simple types of earplugs. They are often made of memory foam so that a user can roll the earplug into a thin rod and fit in the ear canal. The earplug slowly expands to fit in the ear canal. How effective these earplugs work depends on how well the earplug fits and how well the earplug material absorbers sound. One of the characteristics that can change the performance of the earplugs is the pore size in the foam. X-ray CT (computed tomography) can image these foam products non-destructively and analyze the pore sizes.

Analysis procedure

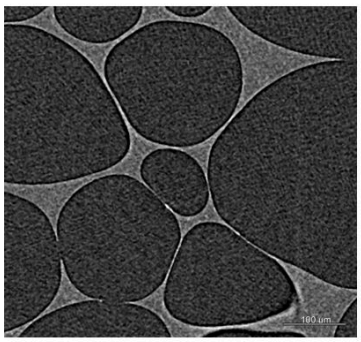
1. In this example, two earplugs were scanned using a submicron-resolution CT scanner, nano3DX.
2. The CT images were segmented into polymer and air.
3. The porosities were calculated from segmented CT images.

1. CT scan

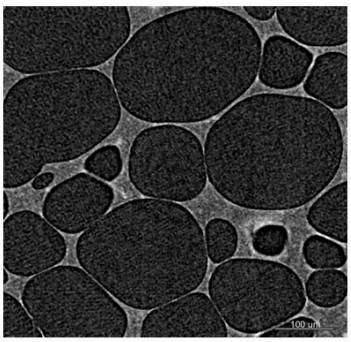
Earplugs from two different store brands were scanned to produce the 3D grayscale CT image. Each scan was done in 20 minutes to minimize the blurring of the image caused by the sample movement.

The gray level in CT images represents the density of the material. Light gray and dark gray represent the polymer and air, respectively. The earplug from store brand A has larger pores than those in the earplug from store brand B.

Store brand A



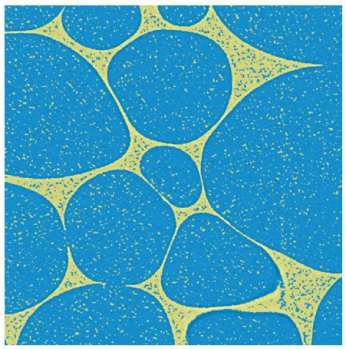
Store brand B



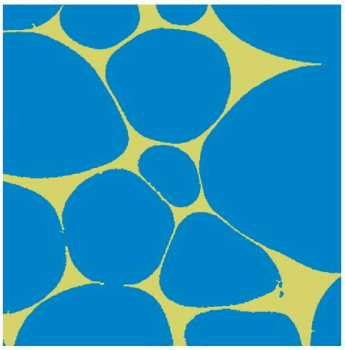
2. Image segmentation

The figure shows a comparison of store brand A segmentation results (polymer in yellow and air in blue) by the thresholding and machine learning segmentation techniques. Due to the relatively short scan time (20 minutes), the noise level is too high for the thresholding technique to cleanly segment the image. Meanwhile, the machine learning technique can provide clean segmentation.

Store brand A – image segmentation



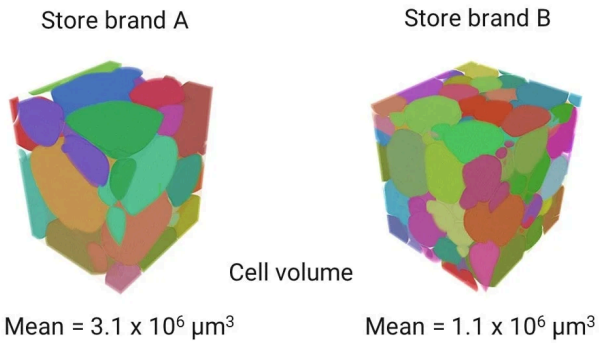
Thresholding



Machine learning

3. Pore size analysis

Using the machine learning segmentation results, the pores were separated by a watershed transformation. The mean pore sizes were calculated to be 3.1e6 and 1.1e6 cubic microns for store brands A and B, respectively.



Extra: 3D rendering of earplug store brand A

This video shows a 3D rendered view and cross-sections of the X-ray CT scan collected on the earplug - store brand A. The polymer is colored purple where it is thick and cream where it is thin. The pores are segmented and rendered at the end of the video.

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