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Effectiveness of A Simple Image Enhancement Method in Characterizing Polyethylene Foam Morphology using Optical Microscopy

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Abstract

A simple image enhancement technique was proposed to observe and analyze cell structure of polyethylene foams using optical microscopy. Two coating techniques were implemented in this study; one being a simple black soot coating and the other utilized a commercial Au/Pd coating that is commonly used for Scanning Electron Microscopy (SEM) observation. The former technique was forwarded after considering that when the sample is white in color, usually microscopic observation via optical microscopy is quite difficult. Polarized light was also applied as another supporting tool to counter the light reflectance problem occurred in the observed white sample. Good quality digital images were successfully produced using both coating techniques with the assistance of polarized light projected via the optical microscope. It was proven that the sample with the proposed black soot coating is able to give high quality image with high level of contrast. The results showed that images with clear cell boundaries were obtained and these images were comparable or much better than those obtained with the Au/Pd coating technique. Finally, images with improved contrast were inverted using an image analysis procedure which allows better determination of foam cell features in polyethylene foams. The use of the proposed technique as supplementary device for real-time microscopic observation during foam compression was also proven to be a success.

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Keywords: Polyethylene foams; optical microscope; black soot; polarized light

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1. Introduction

In principle, there are various techniques that can be utilized to characterize material's morphology such as optical microscopy (OM), scanning electron microscopy (SEM), X-ray micro-tomography, etc. However for polymeric foams, several limitations can be encountered in obtaining a good image. In addition, it becomes more complicated to obtain sufficient high contrast especially when OM is used to define cell walls for closed-cell foams with transparent or white color. Technically, it is complicated due to the cell faces of these materials are able to scatter and/or reflect light thus preventing OM from viewing its interior[1]. This is the reason for most researchers to opt to SEM rather than using OM in characterizing the properties of such foams[2].

There are limited reported studies that focused in addressing the contrast problem faced during characterization of these polymeric foams[3,4]. However, techniques proposed in these studies are only suitable for large foam cell of rigid and semi rigid foams and subsequently become difficult to be applied for flexible foam such as elastomeric foams. The principle of most of the techniques is to reduce light reflectance that often occurred in polyolefin foams which highlighted the cell walls making it optically "blocking" the detection of cell boundaries.

However, in this study, the utilization of optical microscope was preferred due to the motivation in giving greater freedom to researchers in conducting microscopic observation without having to rely heavily on expensive instrument such as SEM. In many developing countries, specialized equipments such as SEM would be a luxury. Even in countries like Malaysia, although the number such facilities are increasing; several drawbacks would create obstacles that might hold back the progress of research activities. Problems such as frequent breakdowns, high maintenance cost, and increasing number of researchers having the same needs for such instrument are some common difficulties faced by researchers in this part of the world. Therefore, the utilization of optical microscopy was proposed to give better solution to these problems thus giving more autonomy to the researchers to dictate the pace of their research activities. In addition, the use of optical microscope for microscopic observation is far more economical and simpler compared to SEM. Optical microscopy is also considered to be a quick, non-contact and non-invasive technique which offers new approaches in fulfilling its requirements besides now having extra features not found in expensive microscopy techniques; e.g. device portability[5].

In view of the abovementioned advantages, there are still a few old problems in utilizing OM in certain microscopic observation. One of them is the inability of OM to create contrasting micrographs if the observation involves a sample that is white in color and having complex morphology such found in polyethylene foams. Due to the transparency of the foam cell walls, the OM images tend to have higher glare occurrence due to multiple light scattering and reflectance of the optical light[1] by the cell walls making it impossible to detect the cell boundaries. The key of solving this glare problem is to reduce the reflection and scattering of light and in this study, a simple glare reduction technique was proposed and tested. The proposed technique was benchmarked with a commercial gold/palladium (Au/Pd) coating technique which is well-known able to give better contrast in Scanning Electron Microscopy (SEM) technique[6,7]. The feasibility of the proposed technique to be used as a supplementary visualization device during real-time monitoring of foam compression was also evaluated.

2. Experimental

2.1 Sample Preparation

Samples were cut into the dimension of approximately 10 x 10 x 5 mm for image analysis purpose. A standard cutting procedure was established to ensure that flat surfaces were obtained in order to acquire good digital images. The samples were cut using sharp shaver blades to avoid implicating cell collapse and the cutting direction was perpendicular to the foam rise direction. The cut foam samples were then subjected to two coating techniques to compare the proposed black soot coating technique with a commercial sputter coating technique.

The first coating technique involved exposing the sample to black soot created from combustion of a kerosene lamp having a setup shown in Fig.1. The effective distance of the samples from the lamp was established (250 mm)