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Scanning Electron Microscopy (SEM) of the Bug Eye and Sand Coral

Sayid Ali Sayid[1], Aliyu Dadan-Garba[2], Daniel Elaigwu Enenche[3], Barnabas Achakpa Ikyo[4*]

[1]Harkness Screens, Stevenage, United Kingdom
[2]Department of Geography, Nigerian Defence Academy, Kaduna, Nigeria
[3]Department of Chemistry, Benue State University, Makurdi, Nigeria
[4]Department of Physics, Benue State University, Makurdi, Nigeria
Email: *aikyo@bsum.edu.ng

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Abstract

We present a Scanning Electron Microscopy (SEM) technique for the characterisation of biological and non-biological samples at nano-scale level. Scanning Electron Microscopy has been around for a long while especially in material science laboratories in developed countries. The SEM has enabled scientist to have a better understanding of microstructure by providing unsurpassed optical magnifications of samples. In this introductory paper, we introduce the techniques of using SEM to capture highly magnified microstructure of a fly found on an African soybean (Glycine max) seed. We are able to estimate the number of lenses in each eye and zoom into features that could describe its life characteristics. Hexagonal lenses are estimated to have sizes ranging from 14 um to 19 um. This paper also presents a finding of a sea coral "pie like structure" on a single grain of sand used for water filtration.

Keywords

Bug Eye, Sand Coral, Scanning Electron Microscopy

1. Introduction

Scanning electron microscope (SEM) is a device that uses a beam of electrons possessing high energy to examine objects at a nano scale [1]. The SEM yields information about the morphology (shape and size of the particles making up the object), topography (surface features of an object), composition (the elements and compounds that make the object and their relative amounts) and crystallographic information (how the atoms are arranged in the object) [2].

Since 1965 when the scanning electron microscope became commercially available, there has been a surge in use of it as a research tool. It has been used successfully in the analysis of organic and inorganic materials on a nanometer to micrometer (μm) scale with great success [3]. The usefulness of the scanning electron beam principle is increasing in microscopy, and many other applications were that its versatility is being harnessed. Although first designed and used in the early 1930's and perfected significantly in the late 1950's, the scanning electron microscope has not found its proper field of application. Possibly the major influence of transmission electron microscopy in almost every field of research was a main cause for this [3].

SEM works to give a high magnification which reaches about 300,000× and up to 1,000,000× in some contemporary models. SEM produces very precise images for an extensive range of materials and works with Energy Dispersive X-ray Spectroscopy (EDS) to provide qualitative and semi-quantitative results [4]. In general, electron microscopes were developed to address the intrinsic limitations of the optical microscopes which could only magnify to about 1000× and give a low resolution. In 1933, the first electron microscopy was constructed based on the works that were conducted by two physicists, Max Knoll and Enrst Ruska in Germany. They developed a Transmission Electron Microscope (TEM) which had the same structure as the existing optical microscope except that a focused beam of electrons was used in place of light to illuminate the sample [5]. A Scanning Electron Microscope provides details surface information by tracing a sample in a raster pattern with an electron beam [6]. As the electrons penetrate the surface of the specimen, many interactions take place leading to the emission of electrons or photons from or through the surface. The SEM works on high voltages between 2 to 50 kV and its beam width is about 5 nm to 2 microns. The SEM produces images from three types of electron interaction with the specimen namely: secondary electron images (SE), backscattered electrons (BSE) and Electron Dispersive Spectroscopy (EDS) utilizing X-ray scattering [7].

For surface topology of the sample, SE is used as it slightly penetrates the sample to give an image for many types of samples (plastics, metals, ceramic, wood and organic matter such as insects as one described in this paper). This technique can be used for chemical composition analysis of the sample surface as the image contrast is dependent upon the atomic number (z-number) of the material's elemental composition. SEM has been used to study fine structures for taxonomy and physiology of insects and mites [7].

This paper introduces a technique used in characterization of organic structure of a soy-bean fly and a sea coral structure on the single grain of sand.

2. Sample Preparation of Soy-Bean Fly

First, the insect was covered in silver dag and held onto the sample holder. Scanning Electron Microscope (SEM) used for this investigation was a state-of-the-art FEI QUANTA 200F. After the sample was loaded into the SEM machine, it was pumped to a high vacuum of about 10 - 6 Torr. **Figure 1** shows the fly eye lens facet at 840× magnifications at 15 kV.

The images in **Figure 2** and **Figure 3** show that the structure is periodic

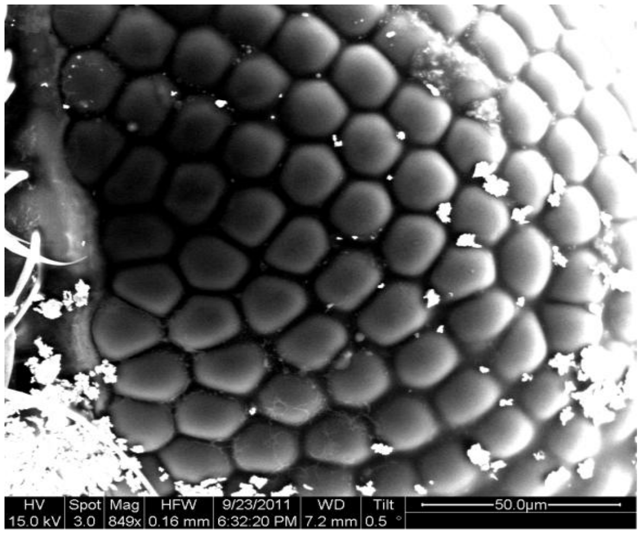

Figure 1. Fly eye lens facet at 840× magnifications at 15 kV.

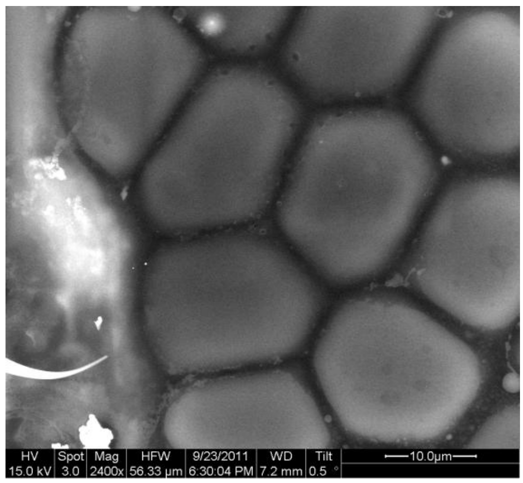

Figure 2. Images taken at 2400× magnification at 15 kV.

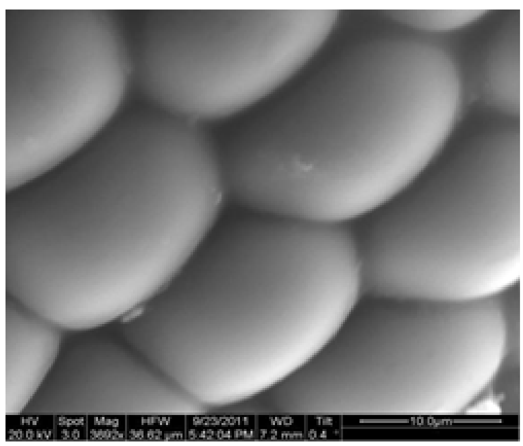

Figure 3. Image of the eye lenses taken at 3700× magnification at 20 kV.

tessellation of hexagonal shapes which are adaptively conforming to the shape of the eye. The images were analysed to determine the length of the lens facet. The summary of length distribution is presented in **Figure 4**.

From the plot in **Figure 4**, the lens facet on this insect ranges from 14 to 19 micron.

3. Sand Particles and Brita Water Filter

Sand particles from sand water filtration system were investigated. Sand filter is reported to be an effective material used in removing small and large particles including other contaminants from water [8]. One of the most significant properties of the sand filtration system is adsorption, a phenomenon resulting from electrostatic attraction between particles, chemical bonding, and mass attraction. Adsorption takes place at every surface at which water comes in contact with a sand grain [9]. According to Huisman [10], water passing over the surface of the sand in a slow sand filter results in sedimentation of smallest particles. SEM technique gives a better visual characterization of the particles in a sand filter system that allows for better understanding of the mechanisms of water filtering in a sand bed. These particles were compared to Brita water filter particles which were taken from new Brita filter. These particles were sprinkled on a separate conductive adhesive sample holder. The aim was to determine the effectiveness of the filtration systems by comparing the sizes of the particulates and their topological characteristics. **Figure 5** presents SEM image of sand particles at 35× magnifications.

From **Figure 5**, it is clear that the sand particles have a wide distribution of both size and shapes. This distribution increases the surface area on which the water and its host of unwanted particles can interact. The distribution of shapes and sizes also enables the particles to have a higher packing ability and yet not hinder the filtration flow-rate. This natural distribution is comparable to Brita filter particle distribution as illustrated in **Figure 6** and **Figure 7**.

We found that filtration of water, the surface characteristics have a larger role in maximising the efficiency. The sizes of the particles in both cases ranged from 300 microns to 1.5 mm.

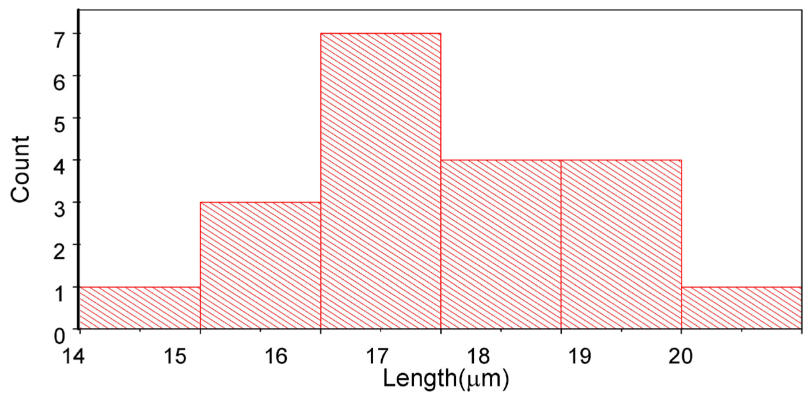

Figure 4. Soy-bean fly lens facet length.

On zooming on the grain of sand a marine structure of about 5-micron radius was found as shown in **Figure 8**.

Presence of these types of structures may explain the efficiency of sand particles to trap contaminants and hence filter the water. It is also worth noting that

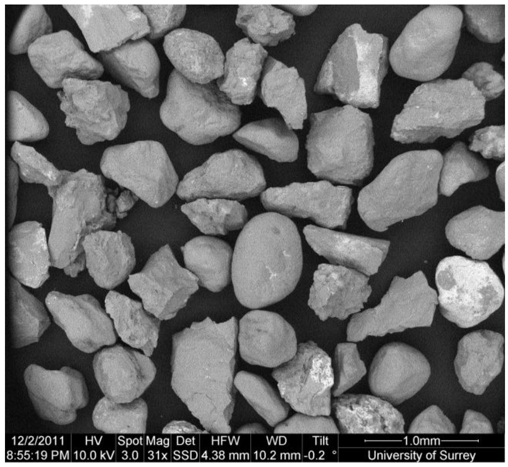

Figure 5. Sand particles shape and size distribution.

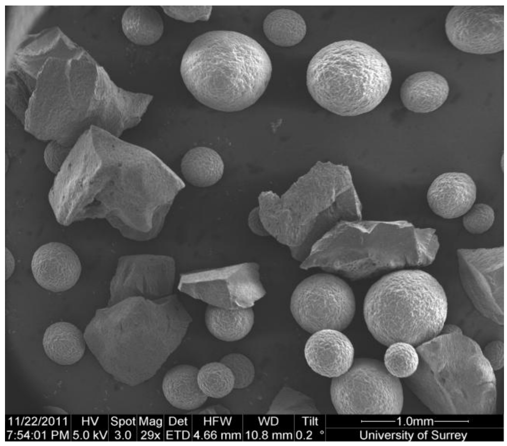

Figure 6. Brita filter particles.

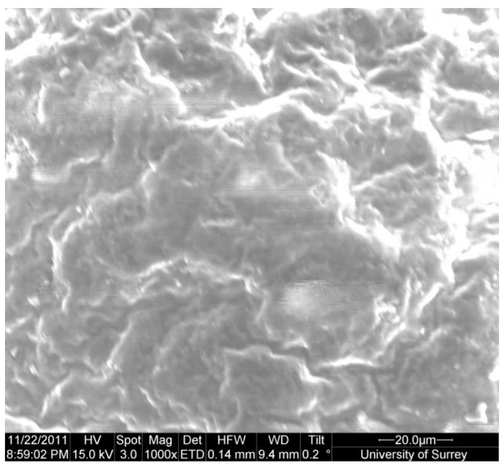

Figure 7. Brita filter particle surface.

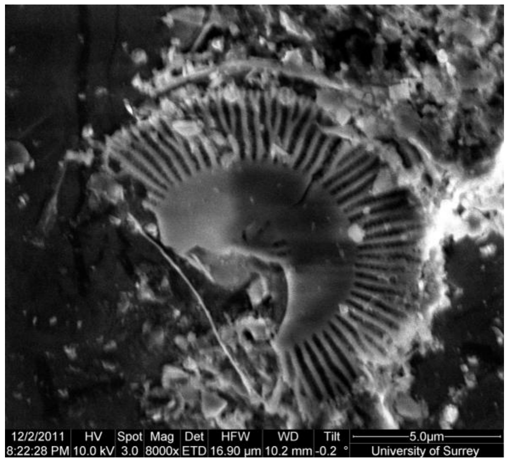

Figure 8. Marine coral structure on a sand particle.

any non- toxic granular particles can be used as filter media due to their characteristics of adsorption, chemical bonding and mass attraction.

4. Conclusions

We present a brief overview of Scanning Electron Microscopy technique to characterise surfaces such as the soy-bean fly eye and the surface characterisation of the sand particles and Brita filter particles used in water filtration systems.

Since the SEM technique enables one to obtain sample images at much higher resolving power and great depth of focus compared to light microscope. We are able to study and analyse surface structure determining the sizes of the interesting features on the objects being characterised.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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