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Fractal structures precipitated from A gall of patient

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Abstract

Three kinds of structures precipitated from the A gall of a patient were observed on the same samples by a field emission gun-scanning electron microscope (FEG-SEM). They were branching fractal structures, dendritic structures, and irregular crystalline grains. The fractal structures consisted of numerous granules that mostly disconnected each other. The dendrites were connected basically together. The tiny crystalline grains were of complicated shapes. A precipitation-aggregation-branching (PAB) model was used to explain growth mechanism of the fractal structure. Energy dispersive X-ray spectroscopy (EDS) was employed to measure chemical composition of three kinds of precipitates, as well as the A gall matrix. The experimental results reveal that saline or salt played an important role to the formation of the fractal structure, and also to that of the dendritic structure and crystalline grain. There may be relationship between the fractal in the A gall sample and fractal in gallstones.

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Keywords: Fractal structure; Dendrite; A gall; Precipitation

1. Introduction

Although the word fractal is relatively new, the shapes associated with this concept was known to scientists, philosophers and artists for a long time [1–5]. A fractal object is self-similar, i.e., a part of the object resembles the whole. Regardless of the size, this resemblance persists forever, if the object is mathematically defined. In nature, however, the measurable range is restricted, on the one hand by the resolution of the measuring equipment and, on the other hand, by the size of the object itself [6–8].

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The concept of fractal has been used widely to investigate complex phenomena often arisen in nature, which can be monitored but not controlled. It explains successfully some nonlinear critical phenomena, and provides a major impetus in research and lead to our improved understanding of many processes. Researchers working in different fields are making an attempt to understand structures and dynamics of various complex phenomena better. Fractal scaling behavior and long-range correlation properties are also observed in many non-equilibrium dynamical systems [9–14].

Cholelithiasis is one of diseases that human being suffers, and some big or small gallstone can be found in different organic parts of human body, such as choledoch, gall duct, biliary passage, and gallbladder. The word "A gall" is the gall secreted from choledoch. Recently, some researchers have been interested in examining relationship between fractal precipitation in gall and gallstone formation [15,16]. In this paper, three kinds of precipitates, fractal structure, dendritic structure, and crystalline grain, formed in a drop of A gall of a patient are reported.

2. Experiment details

A hydrophilic treatment was done to a piece of glass plate. A gall was the eduction from the choledoch of a male patient at 45 after operation. 20 μL fresh A gall of the patient was dropped on the surface of the treated and clean glass plate, and kept at a dry chamber at 4 °C for 2 days. Then, the dried A gall sample was taken out from the dry chamber, and coated with a layer of gold film 10 nm thick for conducting in a vacuum film deposition equipment. The sample was analyzed by a field emission gun-scanning electron microscope (FEG-SEM), model JSM-6301F, JEOL. The chemical compositions of the precipitates and A gall matrix were measured by energy dispersive X-ray spectroscopy (EDS) attached to the FEG-SEM.

3. Results and discussion

3.1. Morphology

There were three different kinds of structures precipitated from the A gall sample, that is, fractal structure, dendritic structure and tiny crystalline grain. Fig. 1(a) shows the FEG-SEM images of a random branching structure precipitated from a drop of A gall, which is a typical fractal structure characterized by self-similarity. The fractal patterns are usually characterized by fractal dimension D shown in Eq. (1)

$$D = \lim_{\xi \to 0} \frac{\log[N(\xi)]}{\log[1/\xi]},$$
$$N(\xi) \to C\xi^{-D}, \quad C = \text{constant}. \tag{1}$$

The box counting method is a useful way to measure the fractal dimension of the fractal

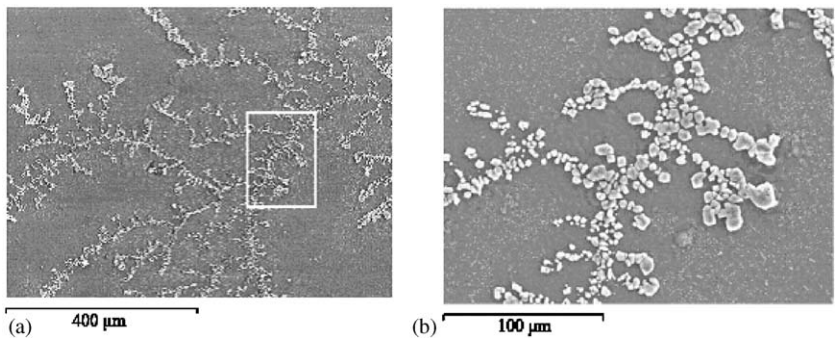

Fig. 1. FEG-SEM images of the precipitates formed in a drop of A gall of a patient. (a) A random branching fractal structure, and (b) closer view of the structure shown in rectangle in Fig. 1(a).