Preliminary Study on Potentials of Pumice as the New Material for Floating Devices and Buoy Products

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***Abstract*— Pumice is a volcanic igneous rock which forms when magma with extremely high levels of water and gases is violently ejected from a volcano (in an explosive eruption), cools and depressurizes quickly and simultaneously above the ground. It is typically light colored, composed of volcanic glass, may or may not contain crystals, and commonly originated from high-silica (felsic) to intermediate magmas. Pumice commonly has vesicular or foamy (porous) texture and very low density, so it is enough for it to become the only rock that can float in water. In this study, pumice is for the first time exposed to see its potential as a new and alternative material to produce floating devices and buoy products. This rock is cut and shaped to become some products, such as surfing boards and lifebuoys. Different from other types of the same kind products that are mostly made of heavy materials, such as plastic (polyethylene), rubber, and fibreglass, pumice-based products are lighter, stronger, more buoyant, more durable, resistant, friendly to users and environmental as well as unique in appearance. Potential markets and customers of these products among others are sport and safety equipments traders and marine transportation (such as ship and ferry) companies. People can use pumice-based surfing boards personally for surfing activity and pumice-based lifebuoys for swimming especially for babies and kids.**

Keywords: Pumice, volcanic igneous rock, volcanic glass, vesicular/foamy texture, floating devices, buoy products.

I. Introduction

The common and existing floating devices and buoy products are created from some materials, such as plastic (polyethylene), rubber, and fibreglass. Some of these materials have low durability, some are non-heat resistant, some are heavy, some are hard and not that safe when in use. Now, it is the time to offer an innovative and alternative choice of floating devices and buoy products which is made of pumice.

Pumice is a volcanic product which forms when magma with extremely high levels of water and gases is violently ejected from a volcano through an explosive eruption, cools and depressurizes quickly and simultaneously above the ground. In addition, pumice is highly vesicular pyroclasts with very low bulk density and thin vesicle walls [1].

The main use of pumice so far is for making lightweight construction materials such as concrete. Small "pumice stones" are commonly used at home or in beauty salons to remove dry skin and calluses from areas such as the feet [2]. Its abrasive qualities make it quite useful. It is often ground into a powder and used in soaps, cleansers, dental products and polishes. Pumice is also used to sculpt ivory and carve stone, and is a common additive in concrete, insulation, plaster and stucco [3].

II. Geological Characteristics of Pumice

Pumice **(Figure 1)** is one of the volcanic igneous rocks (also known as extrusive rocks). It is a light-coloured, very porous igneous rock. It forms through very rapid solidification of a melt. The vesicular texture is a result of gas trapped in the melt at the time of solidification [4]. Extrusive/volcanic rocks are generally formed from lavas – the term for magmas that have flowed onto the surface, either on land or underwater. Pumice (and also tuff) is formed in explosive volcanic eruptions. This pyroclastic rock is porous because of the frothing expansion of volcanic gases when they formed [5].

Pumice is composed of froth-like volcanic glass. It is created when gas-saturated liquid magma erupts like a fizzy drink released from a shaken bottle, and cools so rapidly that the resulting foam solidifies into a glass full of gas bubbles. The hollows in the froth (called vesicles) can be rounded, elongated, or tubular, depending on the flow of the solidifying lava. Pumice has a very low density due to its large number of air-filled pores. As a result, it can easily float in water, and it frequently does when erupted into the sea. Although pumice is mainly composed of glass, small crystals of various minerals do exist, the most common being feldspar, augite, hornblende, and zircon. Pumices formed from silica-rich lavas are white, while those from lavas with intermediate silica content are often yellow or brown, and the rarer silica-poor pumices are black.

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Figure 1. The sample of pumice. The specimen shown is about two inches (five centimeters) across [4].

Macroscopic and microscopic examinations of pumice expose the physical properties of this rock. Examination using naked eyes and a hand lens shows that pumice is typically light colored, vesicular textured, composed of pyroclastic glass, may contains crystal, and commonly silicic or felsic to intermediate in composition. Careful examination under an electron microscope shows that pumice is vesicular across a whole range of scales, from micrometres up to millimetres, sometimes even centimeters **(Figure 2)** [6]. Pumice usually contains a high volume proportion of vesicle void (sometimes as high as 80%). Geological characteristics and other physical properties of pumice are summarized in **Table 1**.

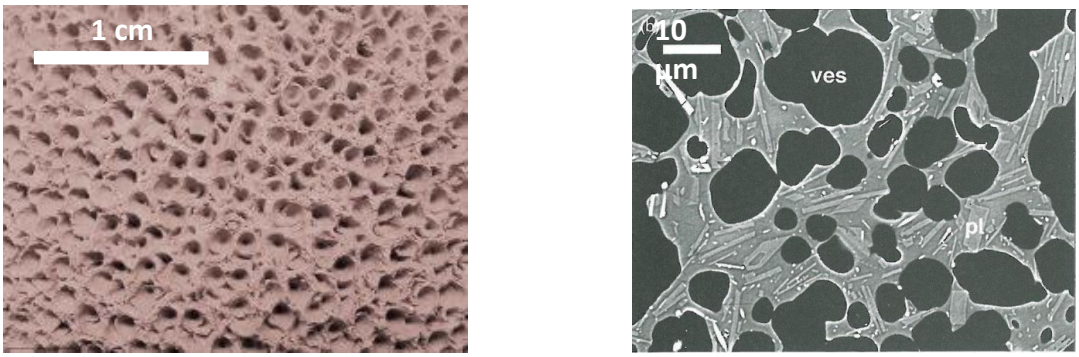

Figure 2. Examination of a pumice: (a) Using a hand lens to show its vesicular texture; (b) Using electron microscope to show more detail its various forms of vesicles (ves) and intervening glass crowded with plagioclase (pl) [6].

Table 1. Geological characteristics and other physical properties of pumice (after [2]; [3])

No.	Property	Remark
1	Color	Pumice is commonly light-coloured, ranging from white, cream, light gray, gray to dark colour. The colour of pumice is determined by the type of magma/lava from which it was formed. White pumice is formed from felsic magma, andesitic pumice (generally yellow or brown) is from intermediate magma, and black pumice is from mafic magma.
2	Texture	Vesicular or foamy texture
3	Composition	Pumice is composed of volcanic glass. It is formed by silica-rich magmas that also create obsidian. Traces of minerals such as feldspar, pyroxene, amphibole and zircon are commonly found in pumice.
4	Density	Pumice is very lightweight. This is due to the air bubbles in it, created as gasses departed during the formation process. Pumice stones vary in density, according to the thickness of the solid material between the bubbles. Average porosity is 90 percent, which is extremely high for a rock material.
5	Buoyancy	Pumice is so lightweight that it will usually float on water for a time, before eventually sinking once becoming waterlogged. Large rafts of pumice have been known to float through oceans for decades after volcanic eruptions.
6	Abrasivity	Pumice is abrasive, which is why it is good at removing dry skin and calluses from the feet. Pumice is also used as an abrasive in polishes, pencil erasers, cosmetic exfoliants and the production of printed circuit boards.

III. PROTOTYPE AND MODEL

The study on potentials of pumice to produce floating devices and buoy products is still in the early stage. Some product examples which are proposed among others are surfing boards and lifebuoys. Prototypes of these products were made by cutting and shaping pumice stones to represent their original forms **(Figure 3)**. A model of a pumice-based surfing board which is floating on water was also created to show how this product is working and functioning **(Figure 4)**.

(a)

(b)

Figure 3. Prototypes and miniatures of some pumice-based products: (a) Surfing board; (b) Lifebuoy.

Figure 4. A model which represents "a surfing board (which is made of pumice) is floating in sea water".

IV. USES AND COMMERCIALIZABILITY

Through this study, pumice is proposed as the new and alternative material for producing floating devices and buoy products, such as surfing boards, lifebuoys, and so on. These buoyant products are able to stand on the water surface for a long time. The material is so light but it is solid, strong and not easily broken. It will never tear and leak as well, so it will surely improve the safety aspect of users. Especially for a pumice-based lifebuoy, it is not such an inflatable and "time-consuming" buoy that needs to be pumped or blown by air before used **(Figure 5)**.

These innovative products are believed to be able to enhance the quality of the existing surfing boards and lifebuoys. They are also believed to be stronger, lighter, more buoyant as well as more durable and resistant than regular ones. Besides, they are assumed to be friendly to users and environmental and have a unique appearance.

Figure 5. Pumice will be proposed as a new and alternative material for producing lifebuoys.

Potential market and customer targets of these products among others are sport and safety equipments traders and marine transportation (such as ship and ferry) agents or companies. People can use pumice-based surfing boards personally for surfing activity and pumice-based lifebuoys for swimming especially for babies and kids.

V. SWOT ANALYSIS

A SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis of pumice-based floating devices and buoy products has highlighted some important characters of them as shown in **Table 2**.

Table 2. SWOT analysis of pumice-based products

Strengths 1. Solid and high durability, because they are made of a rock (pumice). 2. Heat resistant. 3. Lightweight, easy to carry. 4. Eco-friendly product. **5.** For pumice-based lifebuoys: non-inflated (no need to be pumped or blown by air before used or "time saving").	**Weaknesses** 1. Low availability of the raw material in Malaysia. 2. Could not be folded for smaller size.
Opportunities 1. Possibility to develop floating devices and buoy products with offering new material products. **2.** Possibility of growing market for sport and leisure activities, and safety equipment.	**Threats** 1. Competition from the same kind of products made of other materials (plastic, rubber, and fibreglass).

VI. CONCLUSION

Although the existing floating devices and buoy products (for examples in this study are surfing boards and lifebuoys) has so far made of some materials such as plastic, rubber, and fibreglass, it is believed that this is a good idea to search for another material with more quality and better characters. We wish to promote pumice as the new and alternative material for producing floating devices and buoy products, because of its strengths and advantages. Pumice-based products are lighter, stronger, more buoyant, more durable, resistant, friendly to users and environmental as well as unique in appearance. For further studies, however, we need to do the lab tests, including the porosity test, the buoyancy force test, the mechanical strength test, and so on.

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