Jestr

Journal of Engineering Science and Technology Review 15 (2) (2022) 54 - 60

JOURNAL OF
Engineering Science and Technology Review

www.jestr.org

Research Article

Characterization of Sandstone Pore Network using Mercury Porosimetry, Helium Porosimetry and Scanning Electron Microscopy

Paul E. Dim* **and Sean P. Rigby**

Department of Chemical and Environmental Engineering, University of Nottingham, University Park, Nottingham NG7 2RD, U.K.

Received 21 June 2020; Accepted 10 June 2022

Abstract

Porosity and total pore volume are fundamental properties which are vital in gaining a comprehensive insight into the structure of porous rocks. Sherwood sandstone was characterized using Mercury Intrusion Porosimetry (MIP), Helium Intrusion Porosimetry (HIP) and Scanning Electron Microscopy (SEM). The total intrusion pore volume and total porosity increased after treatment. While the bulk density decreased after treatment. The total accessible porosity was higher in the treated sample (26.95 % MIP and 30.67 % HIP) when compared with the raw (7.41 % MIP and 11.06 % HIP). The total pore volume was also larger in the treated sample (0.1538 mL/g MIP and 0.231 gcm-3 HIP) when compared with the raw (0.0775 mL/g MIP and 0.116 gcm-3 HIP). The helium intrusion had a higher result than the mercury intrusion. These results suggest helium due to its small size must have penetrated smaller and finer pores in the rock samples. The modal pore size moved from 14000 to 24000 nm. These results show that treated has more micro, meso, macro and coarse pores than the raw samples. The densities of the samples determined from HIP and MIP decreased after treatment. SEM shows the difference in surface morphology and textural properties. The raw sample was homogenous and displayed a fine grain size, while the treated has loose and less dense-packed pore space distribution. These techniques provided more insight into the assessment of porous solids.

Keywords: Sandstone, Pore network, Porosity, Pore volume, Mercury porosimeter

1. Introduction

Sandstone is a sedimentary rock composed of mainly quartz (silica) grains with other range of materials which include feldspars, shaly, silts, limestone and clays or shales. Sandstones are mainly stratified in a simply superimposed pattern, or with intersecting bed. They usually begin as plant and animal debris transported in lakes and rivers, which accumulate and drop down on the floor of sea and oceans. Eventually, the sediments were buried by sand and other things. They are transformed through evaporation and cementation of sediments to form sandstone.

In most cases, they exist in a mixture of other stones like shale and carbonate. There are three significant categories of sandstone according to their different types of frameworks, namely quartz, feldspar and lithic grains. Sandstone started with single sand grains of different particle sizes, through the depositional process were buried and compressed and eventually resulted in void spaces forming between the sand grains [1, 2]. The successive depositions of sediments at the shore-line or in the form of fluvial or deltaic alluvia resulted in the formation of pore spaces of different sizes. These pores are connected with others to form a porous system; some have one entrance, and some are sealed totally from other void spaces. There are three main groups of voids found in porous solids, some are connected both ends, some have a single connection, and no connection known as sealed voids [1, 2]. The closed pores are not accessible; they terminate within the material. The interconnected through pores permit fluid flow through the material and, hence, are the most crucial pore structure characteristics of the material. The internal structure of sandstone influenced by intergranular areas are vital for understanding fluid flow or transport inside the rock [3]. Researches have shown that pore structure of porous solids can control imbibition in the pulp and paper technology field [4]. It is also responsible for diffusion [5], and fluid flow in porous media [6, 7], and thermal conductivity [8].

Mercury Intrusion Porosimetry (MIP), Scanning electron microscopy (SEM), Helium Intrusion Porosimeter (HIP), X-ray diffraction (XRD), and Transmission electron microscopy (TEM) are generally used for the analysis of porosity and pore properties of rocks and other porous material [9, 10]. It is worth noting; these methods can only probe specific pore size range, and thus cannot assess the properties of a sample independently. Therefore, in this study, HIP, MIP and SEM will be employed. More recently some studies have been reported on characterization of the pore properties of porous materials such as Silica [11], 2014), Coal [9, 12], Rock [6, 13, 14], Graphite [15], Artificial sandstone [16], Cement [17], Catalysts [18] and Alumina [19]. Mercury intrusion technique for long has been in use to characterise the textural properties of porous materials [20]. It is most useful in probing pores between about 0.003 – 400 µm size. This method can provide valuable information, that will aid the assessment of different structural properties or parameters of the solid rock. This feat is achievable only by MIP, but not without its disadvantages. Its access only pore mouth, and not the real size of the pore body. The sealed or isolated pore cannot be analyzed because there is no opening for mercury to invade the pore; the data interpretation relies on model pore geometry [21]. Furthermore, for analysis, it requires drying the small sample

*E-mail address: pevdim@yahoo.com
ISSN: 1791-2377 © 2022 School of Science, IHU. All rights reserved.
doi:10.25103/jestr.152.08