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Innovations in Engineered Mesoporous Material for Energy Conversion and Storage Applications

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Introduction

Today, Earth's population stands at more than seven billions [1]. Along with a constantly growing human population, the living standards are also increasing. Energy is the initial driving force for achieving advancement in human living [2]. As a result of that, the worldwide energy consumption is expected to double within the next 35 years [3]. Fossil fuels such as coal, oil and natural gas have generated most of the energy consumed globally for over a century [4]. But fossil fuels are responsible for a significant amount of land, water and air pollution beyond their carbon dioxide production [5]. Due to large production of carbon dioxide from energy generation, along with emission from vehicles, the earth temperature rises by approximately 2-3°C and it is expected that the same will go up further [1]. This may result into geographical as well as environmental imbalance. To solve these problems, there has been recently a trend towards the increase in the utilization of various renewable energy resources [4]. In this respect, wind power, solar energy, hydrogen geothermal energy, biomass and bio-fuels are extensively investigated for a few decades both from the scientific/academic and industrial/societal viewpoints [6,7].

Figure 1: Renewable energy outlook [8].

Among all the renewable energy resources (Figure 1), wind and solar energy received great attention, as they essentially not required water to operate and thus do not pollute water resources [9]. Solar energy has the most potential, as sun provides the earth with approximately 1,00,000 TW which is almost 10,000 times more than the current energy consumption [10]. Thus abundance of energy makes sun energy very popular for electricity production and hence enhanced their commercialization. Direct utilization of solar radiation to produce electricity is not only way to utilize the nature's renewable energy flow via photovoltaic cells but also power can be generated at the users place. Mesoporous materials have attracted great interest in current years because of the unusual mechanical, electrical and optical properties endowed by confining the dimensions of such materials and because of the combination of bulk and surface properties to the overall behaviour. One needs only the consideration of the staggering developments in microelectronics to appreciate the potential of materials with reduced dimensions. Mesoporous materials are becoming increasingly important for electrochemical energy storage and generation [10,11].

Mesoporous materials are used in many energy applications, because of their owning ability to interact and absorb with guest species on their surfaces, and in the pore spaces [12,13]. The porous materials are classified into three categories according to their pore sizes: mesoporous (2-50 nm), microporous (<2 nm) and macroporous (>50 nm). Since the first report of meso-porous silica [14], many mesoporous materials synthesized under a wide range of pore size PHs from highly basic to strongly acidic conditions, various of shape using non-ionic, cationic, neutral and anionic surfactants [15,16]. These materials have good characteristics such as high surface area, narrow pore size, uniform pore structure etc. The mesoporous materials having large pore volumes, shown promise in the loading of guest species and in the accommodation of the expansion and strain relaxation during repeated electrochemical energy storage processes (Figure 2).

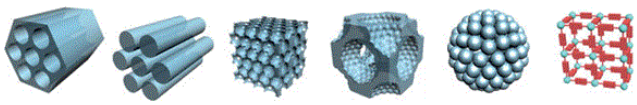

Figure 2: Various type of mesoporous materials.

Moreover, it has high surface areas should provide a large number of reaction or interaction sites for surface processes such as catalysis, adsorption, energy storage and separation. These above features are particularly advantageous for applications in energy conversion and storage [17-19]. The ordered mesoporous materials developed using various templating materials to have attracted increasing interest from the electrochemists community due to their plenty of unique properties and functionalities that can be effectively exploited in optoelectronic devices. Mesoporous materials are excellent opportunities in energy storage and energy conversion applications having to their extraordinarily high surface areas and large pore size. These properties may enhance the performance of porous materials in terms of lifetime and stability, energy and power density.

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