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Research Paper

Proposition of a New Adsorption Refrigeration System Using Activated Carbon Prepared from Olive Stones

Nawel SPAHIS[1, *], Hacene MAHMOUDI[2]

[1] *Faculty of Sciences and Engineering Sciences, Hassiba Ben Bouali University, Chlef, Algeria;* [2]*Laboratory of Water and Environment, Hassiba Ben Bouali University, Chlef, P.O. Box 151, Algeria*

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Abstract: The aim of the current paper is to propose a new solar adsorption refrigerator using a compound adsorbent fabricated from activated carbon issued from olive stones (OS). High efficiency activated carbon (AC) with different chemical characteristic was prepared. It was established that activated carbon is obtained from carbonized olive stones in presence of argon in the temperature range from 700 to 800 °C and activated by $ZnCl_2$ and KOH. The characterization of the activated carbon samples was studied by SEM (scanning electron microscope) technique.

Keywords: *Activated carbon, olive stones, SEM, adsorption, refrigeration system*

Introduction

In many parts of the world, people living in rural and remote areas with no access to electric grid, suffers from food and medical product preservation constraints, which leads to higher levels of disease compared to people living metropolitan areas. During the dry periods with high temperatures, refrigeration unit using solar energy might be used due to the good adaptation with the intermittency conditions (Spahis *et al*., 2007).

The solar adsorption process is mainly based on some solids natural physics properties, which consist of adsorbing gases at low temperatures and realising them at big temperatures. Based on a simple thermodynamic cycle, cold might be generated accordingly. Adsorption machines operate approximately without moving parts. They are mainly, based on the mass of working fluid (gas) adsorbed by selected media. The process have been largely studied during the last twenty years, using appropriate prototypes. The most famous adsorption medias used in adsorption machines were activated carbon-ammonia (Critoph, 1994; Critoph, Metcalf et al., 2004) and (Liu and Leong, 2006), activated carbon (AC)-Methanol (Pons & Grenier, 1987; Mhiri and golli, 1996) and (Lu et al., 2006), zeolite–water (Anyanwu & Ogueke, 2005; Schwarz, 1990) and silica gel–water (Hildbrand et al., 2004).

Highly efficient activated carbon with different chemical properties, can be obtained from carbonized olive Stones. Ferro-García found that AC prepared from olive stones and almond shells presents an excellent adsorption capacity for metal ions (Ferro-García, 1988). In a research paper published by Rodríguez-Reinoso, activated carbon have been synthesized from plum and peach stones (Rodríguez-Reinoso, 1985). Iley and Marsh published a preliminary study on adsorption characteristics of activated carbon generated from olive stones (Iley and Marsh., 1973). Approximatively, big part of the carbonaceous materials can be used to prepare activated carbon (Muñoz-Guillena, 1992). The final chemical qualities depend on the quality and kind of the raw material and highly on the method of preparation (Akash, 1994).

Recently, Spahis et al, (2008), presented a detailed study on the characteristics of AC issued from OS. The authors found that OS, a plentiful agricultural by product in Mediterranean countries, might be an excellent raw material to produce AC with high efficiency. The present work focuses on the possibility of using AC synthesized from OS, in a new adsorption refrigeration machine.

Description of The Adsorption Cycle for Refrigeration

The figure 1 represents a diagram of the periodic of the solar adsorption-cooling machine. The system is composed of a solar reactor made from copper. The reactor contains the adsorbent. The temperature and the pressure have a big influence on the adsorbent; a non-return valves, are used to

[*]*Corresponding: E-mail: n_spahis@yahoo.fr;Tel: +00213777170833; Fax: 00213 27723370*

isolate or connect it to the condenser or to the evaporator. The theoretical cycle is illustrated in the Clapeyron diagram (Figure 2).

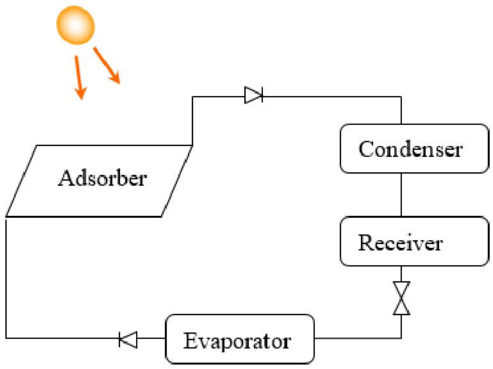

Figure 1. Schematic diagram of simple solar adsorption refrigerator

Figure 1 represents the fundamental refrigeration adsorption cycle which is mainly composed of 4 stages:
State (1) : Solar energy heats the adsorbent, until the refrigerant desorption pressure reached.
State (2) : vapour refrigerant desorption occurs, when adding solar heat. An air-cooled condenser condenses the vapour.
State (3) : When the adsorbent is cooled, and the liquid refrigerant is conducted to the evaporator the pressure in the collector falls down.
State (4) : the adsorbent's temperature keeps run downing, when the liquid refrigerant evaporates and excerpt heat from the evaporator.
The intermittency of the cycle is due to fact that evaporation and cooling process occurs only during the night time.

Results and Discussion

SEM analysis of the activated carbons

The characterization of the surface morphology of the activated carbon prepared from olive stones was conducted by using scanning electron microscopy (SEM) technique. Figure 4 illustrates the SEM pictures of the OS formerly and afterwards the impregnation, using 1000× intensifications. The micrographs show lot of cavities on the outer surface of the chemically AC. The different hollows show non-homogeneous configuration. The cavities differ in size and in shape. It can be noted also, that the cavities resulted from the evaporation of $ZnCl_2$ during carbonization. This means that some salt atoms are distributed around the activated carbon external surface. This might be caused by the existence of residual zinc chloride or other metal complexes on the AC after a bad cleaning (Kula et al., 2007).

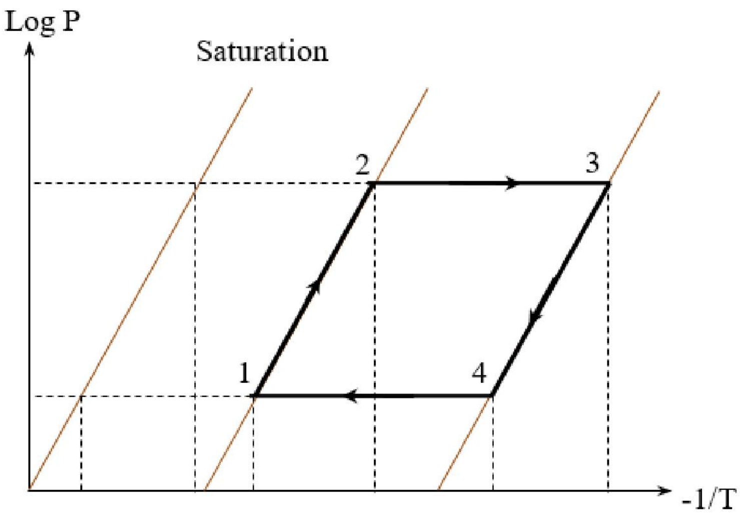

Figure 2 The ideal cycle in the Clapeyron diagram

Materials and Method

Preparation of activated carbon from olive stones (OS)

OS issued from olive oil industry and freed from their fruit were used. The raw material was crushed in a 10% solution of sulphuric acid. In aim to remove the acid traces, the solution was refluxed in distilled water (Spahis et al., 2008)

The first part of crushed olive stones with ray size ranging from 0.25 to 0.5 mm was impregnated using diverse amounts of $ZnCl_2$ and carbonized under constant nitrogen current at 700°C. Different rates of flow at 800°C using a heating rate of 5°C.min-1. Once the carbonization temperature was touched the sample was saved for one hour formerly to the cooling of the furnace to ambient temperature (Figure 3; Spahis *et al*., 2008).

Conversely, the impregnation by KOH demonstrates obviously that it contributes to the growth of the intern microporous hollows which leads to an upper specific surface, the main factor for any adsorption process (Spahis *et al*., 2008)

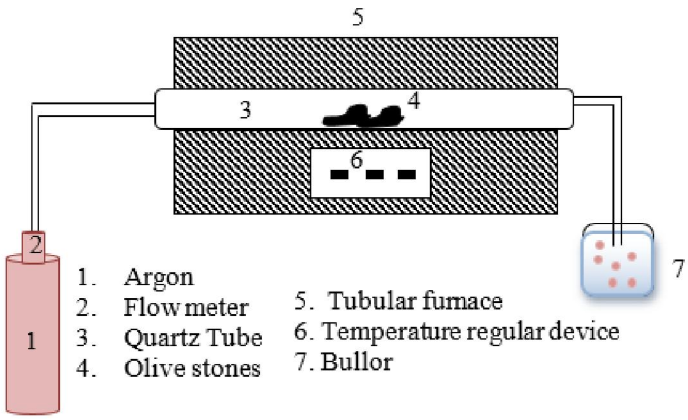

Figure 3. Schematic diagram of the apparatus (Spahis et al., 2008)

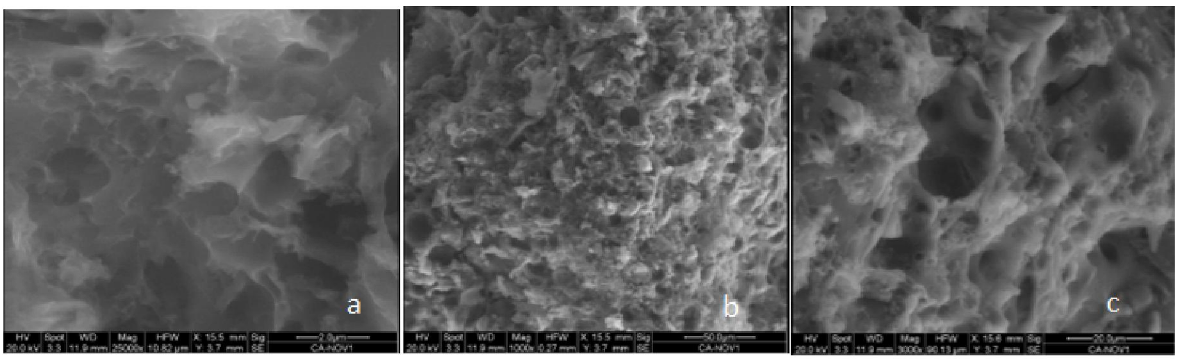

Figure 4. SEMs of (a) no impregned olive stones, (b)olive stones impregned by ZnCl2 (7.35 mmol/g), (c) olivestones impregned by KOH

Conclusion

Synthesis of AC from OS was performed at our laboratory developed in our laboratories. The characterization of the samples presents a high potential for activated carbon to be considered in future adsorption refrigeration machines.

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