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THE INVESTIGATION OF SOME ORGANIC MOLECULAR ADSORBATE EFFECTS ON ABSORPTION ABILITY OF RADIOACTIVE GASES IN ACTIVATED CARBON

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ABSTRACT
Radon is a radioactive gas which is naturally produced by decaying the Uranium atoms into the ground that according to The World Health Organization "WHO", this gas is the second factor for creating lung cancer after smoke. Thereafter identifying and measuring levels of the radon gas especially in the inside buildings, became more worldwide important. The activated carbon detector is one of the devices which use for measuring and monitoring the short-term radon levels in residential buildings, the most basically material at this device is Activated carbon which is active material due to its high absorption ability. This property originates from its internal structure and the production methods. This activity can be detected by gamma detectors such as NAI detector. We have studied the effect of molecular sieve, activated alumina and silica gel on activity of the activated carbon. Our results show that the silica gel material has more effective than molecular sieve and activated alumina materials. This result may be used for optimizing activated carbon detectors.

KEYWORDS: Activated alumina, Activated carbon detector, Molecular sieve, Silica gel.

INTRODUCTION

Activated carbon is a black and tasteless material. It has important and individual application due to remove all of the impurities (without carbon) and surface oxidization. Absorption in this material includes physical and chemical process. Physical absorption involves the attraction by electrical charge difference between adsorbent (carbon) and adsorbate (impurities), but chemical absorption is product of a reaction between the adsorbent and the adsorbate.
The absorption in carbon depends on:
a) Physical and chemical characteristics of the adsorbent (carbon);
b) Physical and chemical characteristics of the adsorbate;
c) Concentration of the adsorbate in liquid solution;
d) Characteristics of the liquid phase (e.g. pH, temperature)
e) The duration that the adsorbate is in contact with the adsorbent (residence time).
Different classification exist for activated charcoal based on the kind of first source which used (granule, powder, extruded, …) and their atomic structure (graphitizing and non- graphitizing carbon). The only undesired parameter in activated charcoal is unselective absorption that is considerable in gas and specific chemical material [2].
Molecular sieve, activated alumina and silica gel are some powerful absorbers and are
Candidates as additive to activated carbon for approving its absorption ability.

MATERIALS AND METHODS

Molecular sieve is a ceramic powder or spherical materials which strongly absorb water, volatile organic compounds (VOC) or both of them. Absorption process in this substance happens one time for ever. On a macro scale this means that the molecular sieve structure is like a long donut or a strand of macaroni – a tiny tube. The VOC molecule can fit inside this tube, but once inside, its size and molecular vibrations prevent it from escaping again. Only small molecules can pass through this tube unimpeded.
The most important classification for them based on their pore sizes which are 13X, 5A, 4A, 3A. [3]

Activated alumina is a white spherical material which is manufactured from aluminum hydroxide by dehydroxylating it in a way that produces a highly porous material; this material can have a surface area significantly more than 200 square meters/g (more than activated charcoal). This material is used for a wide range of adsorbent and catalyst applications in catalysts in relative process, as a selective adsorbent for many chemicals including arsenic, fluoride, as a desiccant, as a filtering system, used to cover surfaces in friction in body protheses (waist and shoulder protheses). It can be regenerated by a solution of sodium hydroxide (NaOH), sulfuric acid (H_2SO_4) or alum ($KAl(SO_4)_2$) [4].

Silica gel is a granular, vitreous, highly porous (more than activated alumina) form of silica made synthetically from sodium silicate. This material can be regenerated by heating it to 120 °C (250 °F) for two hours. When a visible indication of the moisture content of the silica gel is required, ammonium tetrachlorocobaltate (II) ($(NH_4)_2CoCl_4$) or cobalt chloride ($CoCl_2$) is added. It is used to keep the relative humidity (RH), in chromatography as a stationary phase, also used to dry the air in industrial compressed air systems and inhalation devices syringes. It is non-toxic, non-flammable, and non-reactive and stable and will react with hydrogen fluoride, fluorine, oxygen difluoride, chlorine trifluoride, strong acids, strong bases, and oxidizers. This gel can be classified such as different ways of preparation, existence forms, chemical and physical structure and the pour size [5].

Each of above materials according to methods of preparation, their structure and their characteristics has individual absorptive parameters which is useful for absorption. Activated charcoal because of their high absorption and activity ability has been considered for some applications (due to irrevocable combination with impurities and gamma ray production). NaI detector is the most effective and relatively simple device to measure the activity based on gamma ray detecting. In this research we tried to prepare some samples of activated charcoal with equal amounts of 3 other strong adsorbent (silica gel, activated alumina and molecular sieve). The samples were exposed to the radon gas existed in the room air and then these samples were measured by the NaI detector system and according to laboratory setup shown in figure 1.

Conditions in both 2 stages (exposuring and analyzing) completely were similar for all samples for removing the relative error of their measurements. For example every 4 samples are placed in the same plastic granular vial (volume: 140 cm3 and weight: 16 g) at height of 2 meter from the floor and at 25°C during exposure.

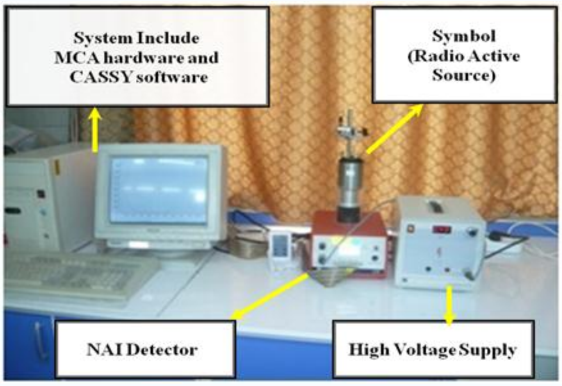

Figure 1. laboratory setup

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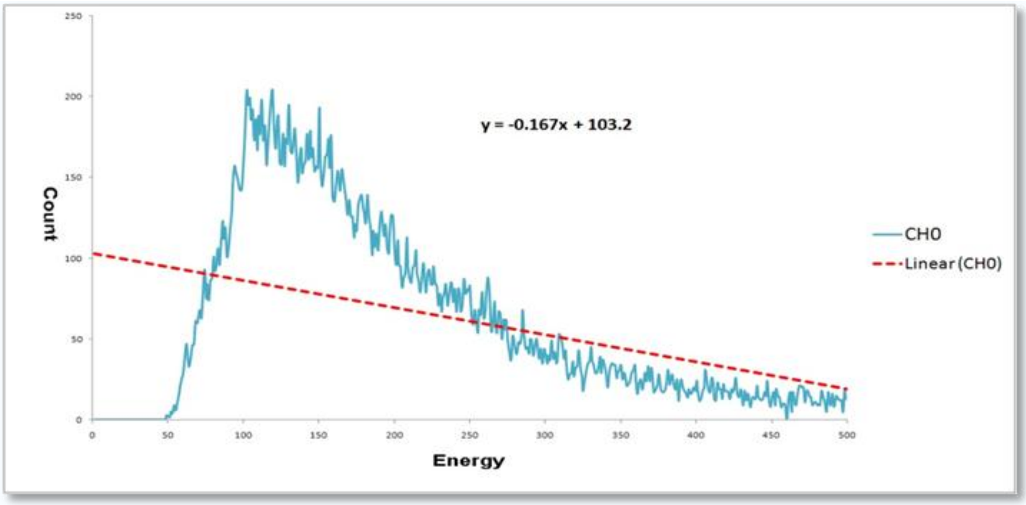

Figure 2. Energy spectrum in CHO

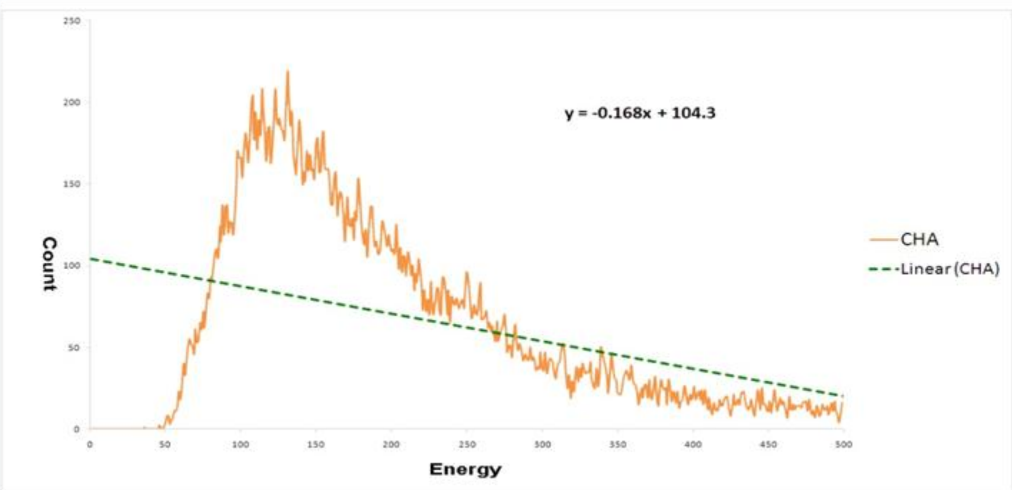

Figure 3. Energy spectrum in CHA

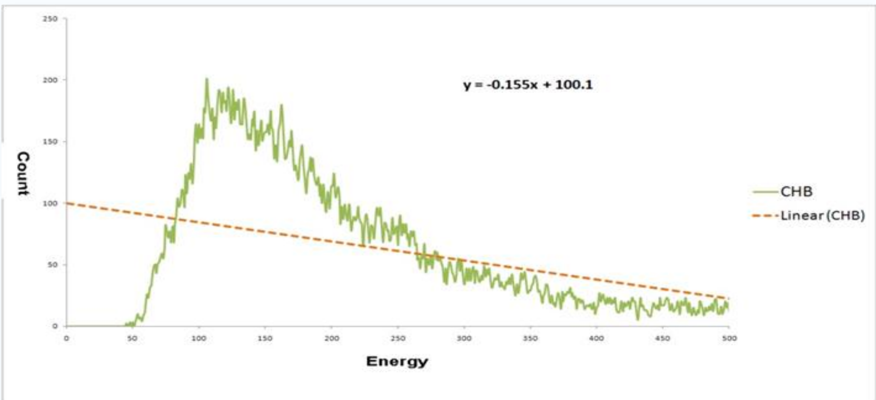

Figure 4. Energy spectrum in CHB

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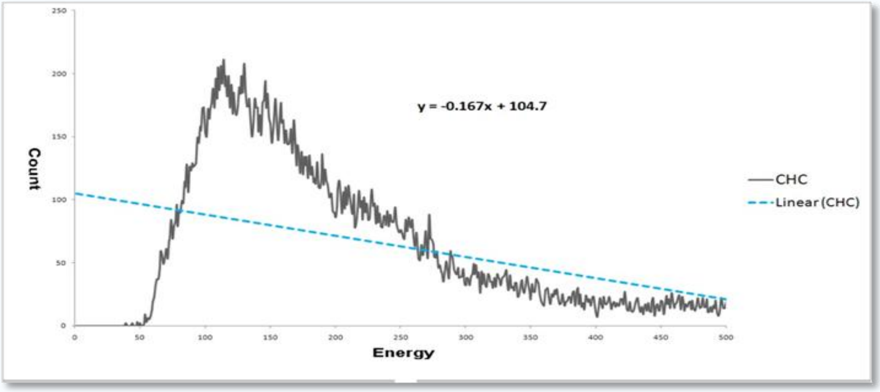

Figure 5. Energy spectrum in CHC

The characteristics of the samples are as below:
CHO: include 20 g activated charcoal,
CHA: include 10 g activated charcoal + 10 g activated alumina,
CHB: include 10 g activated charcoal + 10 g molecular sieve,
CHC: include 10 g activated charcoal + 10 g silica gel,

Measurement system includes a MCA (Multi Channel Analyzer) for determine and register number of gamma particles at each energy channel and Cassy software for calculate and analyze spectrum.
At this research the spectrums did not calibrate due to missing the needed information about the standard energies. So for reduce the relative error percent, all of the samples were analyzed under same conditions (such as: temperature (25°C), voltage (500V) and gate time (600s).

RESULTS
The 4 samples' spectrums are shown in figures 2 to 4. At these figures, the vertical axis determines the count per channel and horizontal axis shows the energy channel. According to the first degree curvilinear fitted on each spectrum, we can find difference and lack of conformity between them. By comparing the X coefficient in above linear equations, it can be seen that negative amount in CHA is the most and in CHB is the least but in 2 other samples this amount is equal. This is also the same with compare the constant number of this curvilinear, it can be seen that the most amount is in CHA and in CHB is the least. The results of the 2 comparisons show that CHB include activated charcoal and molecular sieve has the least absorption and activity against the CHC include activated charcoal with silica gel which has the most amounts of absorption and activity. According to high absorption area in silica gel (over 800 cm^3/g), this conclusion is predictable and acceptable.

In the latest stage of these analyzes, for investigate truth and accuracy of the above results; we calculated the end amount of samples activity. For this reason by use of nuclear physics standard tables, decay constant and half-life of reference source (cobalt-60) was determined. Then through formula 1, its activity was calculated. At the end, the activity of the samples (U) is determined by using reference source (S) via measuring the area which is laying under the curves and then replace it in formula 2. The results are shown in table 1.

(1) $$A = A_0 e^{-\lambda t}$$

(2) $$\frac{U_{activity}}{S_{activity}} = \frac{\sum U - \sum b}{\sum S - \sum b}$$

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Table 1: Calculated activity in 4 samples

Sample	CHO	CHA	CHB	CHC
Activity (Bq)	139.5	141.4	139.7	141.9

RESULTS AND DISCUSSION

The above results show that if any of the molecular adsorbent (silica gel, activated alumina and molecular sieve) is added to activated charcoal, the absorption amount and activity of mixture will be increased. By the way the effect of silica gel on improving of absorbing ability of active carbon is better than others.

*According to table 1 and above discussions, the amount of activity in the sample which includes **activated charcoal and silica gel** is higher than other samples.*

- The material that use in this research were molecular sieve, activated alumina, granular activated carbon which was produced in Merck company (Germany) and an Iranian company with the highest purities.

- The used NaI detector was a Germany's company product (Leybold). The important and basic purpose of this research was planned for the determination of improvement the indoor radon measurement using activated charcoal.

Actually according to the result of this paper we could remove the humidity effect in radon measurements by activated charcoal.

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