Porosity Measurements of Positive of Lead-Acid Battery Plates by Mercury PSorosimetry

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Received 12, March, 2009
Acceptance 7, September, 2009

Abstract:

A mercury porosimeter has been used to measure the intrusion volume of the three types mercury positive lead acid-battery plates. The intrusion volumes were used to calculate the pore diameter, pore volume, pore area, and pore size distribution. The variation of the pore area in positive lead acid-battery plates as well as of the pore volume has the following sequence.

Paste positive > Uncured positive > Cured positive

Key word: porosity measurements, lead-acid battery plates.

Introduction:

The grid make an important part of storage cell which act as supports for the active materials of plates and conduct the electric current developed. It also play an important role in maintaining uniform current distribution throughout the mass of the active material. Grids for both positive and negative plates are frequently of the same design, composition, and weight[1]. The surfaces area of active material depend on curing temperature, as the suitable temperature in curing process is around (56 – 65^{o}C)[2], porous materials are being used as molecular sieve , catalysis – humidity sensors , and contaminant barriers .In particular recent studies propose that the use of micro porous (pores<2nm) and malodorous(pores 250 nm) minerals as adsorbents for pollutants in aqueous systems[3] .

The phase composition and the microstructure of the positive plate active material of the lead-acid battery depend to a large extent on the paste from which the active material has been produced . The paste is obtained by mixing partially oxidized lead powder with a sulphuric acid solution . It has been established that basic lead sulphates form in these conditions . At room temperature $3PbO.PbSO_4.H_2O$ is generated , while at a mixing temperature of 70^{o}C $4PbO.PbSO_4$ because of its very interesting structure . The properties of plates obtained form previously synthesized pure $4PbO.PbSO_4$ have studied[4]. The porous structure can be characterized by integral or differential curves of porevolume distribution vs. pore radius (porosimetric curves or porograms).

The following methods for measuring porograms are well known: mercury porosimetry - mercury intrusion into a nonwettable porous material , small-angle X-ray scattering ,electronic or optical microscopy; centrifugal porosimetry , displacement of wetting liquids from the porevolume by gas pressure ,capillary condensation. The method of mercury porosimetry (MMP) provides the widest range of measurable pore radii (from 2 to 105 nm). Great disadvantage of this method is the necessity to apply high pressure of mercury (up to thousands of

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atmospheres), which can lead to deformation or even destruction of the samples and to distortion of the porograms. Other drawbacks of this method are: misrepresentation of the results due to amalgamation of most metals , different values of the mercury wetting angle for different materials, complexity of the equipment, toxicity of mercury[5].

A new method of standard porosimetry for investigation for any type of porous materials was also shown to be suitable to determine the effective porosity of cured and formed positive plate lead-acid storage battery[6]. The present work, pore size, pore volume and pore surface area of the positive plate at lead-acid storage battery have been measured by usingmercury intrusion porosimeter. No such data are available in the literature.

Material and Methods:

The measurements were made using mercury porosimeter model "pore size 9320", obtained from micromeritics, USA. The mercury porosimeter[7,8] is a device which was capable of generating suitably high pressures and measuring simultaneously both the pressure and volume of the mercury token up by the pores .

A measurement with gravitas was carried out as follows: on analytical balance the materials of lead battery specimen to be examined was weighted and dried in vacuum oven at ($120C^o$) for over night. After drying process the specimen was transferred to the low pressure chamber and the measurements proceeded automatically recording the pressure (in psia) and intrusion reading (in PF) (PF = pico farad). The same procedure was employed after the sample was transferred to the high pressure chamber. The duration time of the experiment lasted about 5 hours. Six types of specimens which have been received directly from ministry of industrial, Babel factory for manufacturing lead acid batteries, Baghdad the sample of the lead battery which have been used in this investigation;

1- Uncured positive plate of the battery. This represented a grid, which was coated with the paste of the positive plate prior to curing stage.

2- Accrued positive plate of step (2).

The samples were ground then sieved and the powder whose the partial size (250 µm) have been used.

Results and Discussion:

The properties of the lead oxide vary markedly with the method of manufacture, compared to ball-mill oxides, Barton oxide, generally have lager particle-size distributions and mean particle diameters.

The porosity measurements enabled the identification of pore volume, pore size, pore area, and the most abundant pores that are present in the mater sales . (table 1) shows typical pore size distribution data form and pore area distribution data form for lead battery .Calculating the pore diameter introduced by mercury at each pressure requires solving the basic equation[9,10]

$$D = -4\gamma \cos\frac{\theta}{P} \quad ....(1)$$

Where

D = the pore diameter in units of micro meter.

γ = the surface tension of mercury 485 dynes/cm.

θ = the contact angle between mercury and the solid containing the pores and generally varies around 30 degrees.

p = the pressure in pounds per square inch.

Converting intrusion meter readings to pore volumes requires first, calculate the cumulative changes in capacitance (Initial value taken as zero).

These changes in capacitance multiplied by the conversion factor (pentrometer constant) supplied for the penetrometer (and a units conversion factor) to give the cumulative pore volume. Cumulative pore volumes per gram of sample are obtained by dividing by the weight of the sample. The total pore surface area obtained by assuming that all the pores are cylindrical capillaries. The calculate the pore surface area A for each diameter increment is simply related to incremental pore(V) and the average pore diameter (D) by the equation[11] ;

$$A = \frac{4V}{D} \qquad ....(2)$$

The cumulative surface area for each point is the sum of these for all points . Table (2) shows the experimental values of pore volume, pore area and median pore diameter on the three samples of lead acid batteries in Baghdad. The value of (D) on the distribution curve corresponding to the maximum value of ΔV/ΔD is termed the media pore diameter. The results of table (3) refer that pore area and pore volume of the three samples of lead acid batteries , follows the sequence as;

Paste positive > Uncured positive > Cured positive

The different pore size distributions were estimated from the plot ΔV/ΔD against D. ΔV and ΔD is obtained from differences cumulative volume and pore diameter points in table (2).

The data obtained are tabulated in table (4) and shown in fig (1-3)

Table (1) Pore volume and pore area for paste positive electrode (Ball Mill Method)

Pressure (pounds/in^2)	Pore Size (µm)	Intrusion Reading (PF)	Cumulative Intrusion (∑ΔPF)	Cumulative pore volume (cc/g)	Average Pressure	Incremental pore volume (cc/g)	Average Pore Size (µm)	Incremental Pore arca (m^2 / g)	Cumulative Pore arca (m^2 / g)
١,٣	١٣٩,١٣٠	٣٧,٢٣	٠	٠	٠	٠	٠	٠	٠
٢,٣	٧٨,٦٣٩	٣٦,٤٤	٠,٧٩	٠,٠١٥٥	١,٨	٠,٠١٥٥	١٠٠,٤٨٣	٠,٠٠٠٦١٧	٠,٠٠٠٦١٧
٣,٢	٥٦,٥٢١	٣٥,٤٠	١,٨٣	٠,٠٣٥٩	٢,٧٥	٠,٠٢٠٤	٦٥,٧٧٠	٠,٠٠١٢٤	٠,٠٠١٨٥٧
٣,٧	٤٨,٨٨٣	٣٤,١٩	٣,٠٤	٠,٠٥٩٩	٣,٤٥	٠,٠٢٤	٥٢,٤٢٦	٠,٠٠٠١٨٣	٠,٠٠٢٠٤
٤,٩	٣٦,٩١٢	٣٢,٨٠	٤,٤٣	٠,٠٨٧١	٤,٣	٠,٠٢٧٢	٤٢,٠٦٢	٠,٠٠١٥٨	٠,٠٠٤٦٢
٥,٧	٣١,٧٣١	٣٢,٢٦	٤,٩٧	٠,٠٧٨٧	٥,٣	٠,٠١٠٧	٣٤,١٢٦	٠,٠٠١٢٥	٠,٠٠٥٨٧
٦,٦	٢٧,٤٠٤	٣١,٧٢	٥,٥١	٠,١٠٨٤	٦,١٥	٠,٠١٠٦	٢٩,٤٠٩	٠,٠٠١٤٤	٠,٠٠٧٣١
٧,٦	٢٣,٧٩٨	٣١,٢٨	٥,٩٥	٠,١١٧٢	٧,١	٠,٠٠٨٨	٢٥,٤٧٤	٠,٠٠١١٩	٠,٠٠٨٥
٨,٧	٢٠,٧٨٩	٣١,٠٧	٦,١٦	٠,١٢١٢	٨,١٥	٠,٠٠٤	٢٢,١٩٢	٠,٠٠٠٧٢	٠,٠٠٩٢٢
٩,٧	١٨,٦٤٦	٣٠,٨٨	٦,٣٥	٠,١٢٥١	٩,٢	٠,٠٠٣٩	٢٠,٠٩٦	٠,٠٠٠٧٧	0.00999
١٠,٩	١٦,٥٩٣	٣٠,٧٩	٦,٤٤	٠,١٢٦٧	١٠,٣	٠,٠٠١٦	١٧,٥٦٠	٠,٠٠٠٣٦	٠,٠١٠٣٥
١١,٨	١٥,٣٢٧	٣٠,٧٠	٦,٥٣	٠,١٢٨٥	١١,٣٥	٠,٠٠١٨	١٥,٩٣٥	٠,٠٠٠٤٥	٠,٠١٠٨
١٣,١	١٣,٨٠٦	٣٠,٦٦	٦,٥٧	٠,١٢٩٣	١٢,٤٥	٠,٠٠٠٨	١٤,٥٢٧	٠,٠٠٠٢٢	٠,٠١١٠٢
١٣,٣	١٣,٥٩٩	٣٠,٦٣	٦,٦	٠,١٣٠٠	١٣,٢	٠,٠٠٠٧	١٣,٧٠٢	٠,٠٠٠٢٠	٠,٠١١٢٢
١٣,٩	١٣,٠١٢	٣٠,٦١	٦,٦٢	٠,١٣٠٤	١٣,٦	٠,٠٠٠٤	١٣,٢٩٩	٠,٠٠٠١٢	٠,٠١١٣٤
٣٠٣	٠,٥٩٦	٣٣,١٥	٦,٦٢	٠	٠	٠	٠	٠	٠
٤٨٨	٠,٣٧٠	٣٢,٧٢	٧,٠٥	٠,١٣٨٨	٣٩٥,٥	٠,٠٠٨٤	٠,٤٥٧٣	٠,٠٧٣٤	٠,٠٨٤٧
٨٨٢	٠,٢٠٥	٣٢,٣٠	٧,٤٧	٠,١٤٧٢	٦٨٥	٠,٠٠٨٤	٠,٢٦٤	٠,١٢٧٢	٠,٢١١٩٤
١٤٦٢	٠,١٢٣	٣١,٦٦	٨,١١	٠,١٥٩٨	١١٧٢	٠,٠١٢٦	٠,١٥٤	٠,٣٢٧٢	٠,٥٣٩١٣
٢٣٧٧	٠,٧٦	٣١,٠	٨,٧٧	٠,١٧٢٧	١٩١٩,٥	٠,٠١٢٩	٠,٠٩٤٢	٠,٥٤٧٧	١,٠٨٦٨٤
٣٨٩٠	٠,٠٤٦	٣٠,٦١	٩,١٦	٠,١٨٠٤	٣١٣٣,٥	٠,٠٠٧٧	٠,٠٥٧٧	٠,٥٣٣٧	١,٦٢٠٥٤
٥٣٧١	٠,٠٣٣	٣٠,٤٩	٩,٢٨	٠,١٨٢٨	٤٦٣٠,٥	٠,٠٠٢٤	٠,٠٣٩٠	٠,٢٤٦١	١,٨٦٦٦٤
٧٦٥٠	٠,٠٢٣	٣٠,٤٠	٩,٣٧	٠,١٨٤٦	٦٥١٠,٥	٠,٠٠١٨	٠,٠٢٧٧	٠,٢٥٩٩	٢,١٢٦٥٤
٩٩٥٠	٠,٠١٨	٣٠,٣٤	٩,٤٣	٠,١٨٥٧	٨٨٠٠	٠,٠٠١١	٠,٠٢٠٥	٠,٢١٤٦	٢,٣٤١١٤
١١٢٥٥	٠,٠١٦	٣٠,٣٤	٩,٤٩	٠,١٨٥٧	١٠٦٠٢,٥	٠,٠٠٠	٠,٠١٧٠	٠,٠٠٠	٢,٣٤١١٤
١٢٩١٣	٠,٠١٤	٣٠,٣٢	٩,٤٥	٠,١٨٦١	١٢٠٨٤	٠,٠٠٠٤	٠,٠١٤٩	٠,١٠٧٣	٢,٤٤٨٤٤
١٣٨٧٩	٠,٠١٣	٣٠,٣٠	٩,٤٧	٠,١٨٦٤	١٣٣٩٦	٠,٠٠٠٣	٠,٠١٣٥	٠,٠٨٨٨	٢,٥٣٧٢٤
١٤٥٦١	٠,٠١٢٤	٣٠,٢٩	٩,٤٨	٠,١٨٦٦	١٤٢٢٠	٠,٠٠٠٢	٠,٠١٢٧	٠,٠٦٢٩	٢,٦٠٠١٤
١٥٠١٠	٠,٠١٢٠	٣٠,٢٨	٩,٤٩	٠,١٨٦٨	١٤٧٨٥,٥	٠,٠٠٠٢	٠,٠٢٢	٠,٠٦٥٥	٢,٦٦٥٦٤

Table (2) Pore volume and pore area for cured positive electrode(Ball Mill Method)

Pressure (pounds/in^2)	Pore Size (µm)	Intrusion Reading (PF)	Cumulative Intrusion (∑ΔPF)	Cumulative pore volume (cc/g)	Average Pressure	Incremental pore volume (cc/g)	Average Pore Size (µm)	Incremental Pore arca (m^2 / g)	Cumulative Pore arca (m^2 / g)
٠,٧	٢٥٨,٣٨٥	٣٧,٦٨	٠	٠	٠	٠	٠	٠	٠
١,٦	١١٣,٠٤٣	٣٧,٥١	٠,١٧	٠,٠٠١٠	١,١٥	٠,٠٠١	١٥٧,٢٧٨	٠,٠٠٠٠٢٥	٠,٠٠٠٠٢٥
٢,٤	٧٥,٣٦٢	٣٧,٢٠	٠,٤٨	٠,٠٠٢٨	٢,٠	٠,٠٠١٨	٩٠,٤٣٥	٠,٠٠٠٠٧٩	٠,٠٠٠١٠٤
٣,٢	٥٦,٥٢١	٣٦,٣٠	١,٣٨	٠,٠٠٨٣	٢,٨	٠,٠٠٥٥	٦٤,٥٩٦	٠,٠٠٠٣٤٠	٠,٠٠٠٤٤٤
٤,٦	٣٩,٣١٩	٣٥,٤٤	٢,٢٤	٠,٠١٣٥	٣,٩	٠,٠٠٥٢	٤٦,٣٧٦	٠,٠٠٠٤٤٨	٠,٠٠٠٨٩٢
٦,١	٢٩,٦٥٠	٣٤,٨١	٢,٨٧	٠,٠١٧٣	٥,٣٥	٠,٠٠٣٨	٣٣,٨٠٧	٠,٠٠٠٤٤٩	٠,٠٠١٣٤٧
٧,٤	٢٤,٤٤١	٣٤,٥٤	٣,١٤	٠,٠١٨٩	٦,٧٥	٠,٠٠١٦	٢٦,٧٩٥	٠,٠٠٠٢٣٨	٠,٠٠١٥٧٩
٩,٠	٢٠,٠٩٦	٣٤,١٤	٣,٥٤	٠,٠٢١٣	٨,٢	٠,٠٠٢٤	٢٢,٠٥٧	٠,٠٠٠٤٣٥	٠,٠٠٢٠١٤
١٠,١	١٧,٩٠٧	٣٤,٠٢	٣,٦٦	٠,٠٢٢١	٩,٥٥	٠,٠٠٠٨	١٨,٩٣٩	٠,٠٠٠١٦٨	٠,٠٠٢١٨٢
١٠,٩	١٦,٥٩٣	٣٣,٩٠	٣,٧٨	٠,٠٢٢٨	١٠,٥	٠,٠٠٠٧	١٧,٢٢٥	٠,٠٠٠١٦٢	٠,٠٠٢٣٤٤
١١,٨	١٥,٣٢٧	٣٣,٧٩	٣,٨٩	٠,٠٢٣٥	١١,٣٥	٠,٠٠٠٧	١٥,٩٣٥	٠,٠٠٠١٧٥	٠,٠٠٢٥١٩
١٢,٣	١٤,٧٠٤	٣٣,٧٠	٣,٩٨	٠,٠٢٤٠	١٢,٠٥	٠,٠٠٠٥	١٥,٠٠٩	٠,٠٠٠١٣٣	٠,٠٠٢٦٥٢
١٣,٣	١٣,٥٩٩	٣٣,٦٢	٤,٠٦	٠,٠٢٤٥	١٢,٨	٠,٠٠٠٥	١٤,١٣٠	٠,٠٠٠١٤١	٠,٠٠٢٧٩٣
١٣,٤	١٣,٤٩٧	٣٣,٥٧	٤,١١	٠,٠٢٤٨	١٣,٣٥	٠,٠٠٠٣	١٣,٥٤٨	٠,٠٠٠٠٨٨	٠,٠٠٢٨٨١
١٣,٨	١٣,١٠٦	٣٣,٥١	٤,١٧	٠,٠٢٥١	١٣,٦	٠,٠٠٠٣	١٣,٢٩٩	٠,٠٠٠٠٩٠	٠,٠٠٢٩٧١
١٤,٠	١٢,٩١٩	٣٣,٤١	٤,٢٧	٠,٠٢٥٨	١٣,٩	٠,٠٠٠٧	١٣,٠١٢	٠,٠٠٠٢١٥	٠,٠٠٣١٨٦
٣٣٠	٠,٥٤٨	٣١,١٥	0	٠	٠	٠	٠	٠	٠
٤٥١	٠,٤٠١	٣١,١٠	٤,٣٢	٠,٠٢٦١	٣٩٠,٥	٠,٠٠٠٣	٠,٤٦٣	٠,٠٠٢٥٩	٠,٠٠٥٧٧٦
٦٠٠	٠,٣٠١	٣١,٠٣	٤,٣٩	٠,٠٢٦٥	٥٢٥,٥	٠,٠٠٠٤	٠,٣٤٤	٠,٠٠٤٦٥	٠,٠١٠٤٢٦
١١٩٨	٠,١٥٠	٣٠,٨٥	٤,٥٧	٠,٠٢٧٦	٨٩٩	٠,٠٠١١	٠,٢٠١	٠,٠٢١٨٩	٠,٠٣٢٣١٦
٢٠٩٠	٠,٠٨٦	٣٠,٧٠	٤,٧٢	٠,٠٢٨٥	٣٢٨٨	٠,٠٠٠٩	٠,٠٥٥	٠,٠٦٥٤٥	٠,٠٩٧٧٦٦
٣١٣٣	٠,٠٥٧	٣٠,٤٧	٤,٩٥	٠,٠٢٩٩	٢٦١١,٥	٠,٠٠١٤	٠,٠٦٩	٠,٠٨١١٥	٠,١٧٨٩١٦
٤١١٦	٠,٠٤٣	٣٠,٢٤	٥,١٨	٠,٠٣١٣	٣٦٣٤,٥	٠,٠٠١٤	٠,٠٤٩	٠,١١٤٢٨	٠,٢٩٣١٩٦
٦٧١٩	٠,٠٢٦	٣٠,٠٩	٥,٣٣	٠,٠٣٢٢	٥٤١٧,٥	٠,٠٠٠٩	٠,٠٣٣	٠,١٠٩٠٩	٠,٤٠٢٢٨٦
٩١٦٦	٠,٠١٩	٣٠,٠٠	٥,٤٢	٠,٠٣٢٧	٧٩٤٢,٥	٠,٠٠٠٥	٠,٠٢٢	٠,٠٩٠٩٠	٠,٤٩٣١٨٦
١٠٠٠٥	٠,٠١٨	٢٩,٩٧	٥,٤٥	٠,٠٣٢٩	٩٥٨٥	٠,٠٠٠٢	٠,٠١٨	٠,٠٤٤٤٤	٠,٥٣٧٦٢٦

Table (3) Pore volume and pore area for uncured positive electrode(Ball Mill Method)

Pressure (pounds/in^2)	Pore Size (µm)	Intrusion Reading (PF)	Cumulative Intrusion (∑ΔPF)	Cumulative pore volume (cc/g)	Average Pressure	Incremental pore volume (cc/g)	Average Pore Size (µm)	Incremental Pore arca (m^2 / g)	Cumulative Pore arca (m^2 / g)
٠,٨	٢٢٦,١	٣٨,٥٠	٠	٠	٠	٠	٠	٠	٠
١,٥	١٢٠,٦	٣٨,٣٦	٠,١٤	٠,٠٠٢٥	١,١٥	٠,٠٠٢٥	١٥٧,٣	٠,٠٠٠٠٦	٠,٠٠٠٠٦
٢,٣	٧٨,٦	٣٧,٨٩	٠,٦١	٠,٠١١١	١,٩٠	٠,٠٠٨٦	٩٥,٢	٠,٠٠٠٣٦	٠,٠٠٠٤٢
٣,٢	٥٦,٥	٣٧,٣٠	١,٢٠	٠,٠٢١٨	٢,٧٥	٠,٠١٠٧	٦٥,٨	٠,٠٠٠٦٥	٠,٠٠١٠٧
٤,٤	٤١,١	٣٦,٥٨	١,٩٢	٠,٠٣٤٩	٣,٨٠	٠,٠١٣١	٤٧,٦	٠,٠٠١٠١	٠,٠٠٢٠٨
٥,٦	٣٢,٣	٣٥,٧٢	٢,٧٨	٠,٠٥٠٦	٥,٠٠	٠,٠٢١١	٣٦,٢	٠,٠٠٢٣٣	٠,٠٠٤٤١
٦,٨	٢٦,٦	٣٥,٢٢	٣,٢٨	٠,٠٥٩٧	٦,٢٠	٠,٠٠٩١	٢٩,٢	٠,٠٠١٢٥	٠,٠٠٥٦٦
٨,٣	٢١,٨	٣٦,٧٢	٣,٧٨	٠,٠٦٨٩	٧,٥٥	٠,٠٠٩٢	٢٤,٠	٠,٠٠١٥٣	٠,٠٠٧١٩
٩,٨	١٨,٥	٣٤,٣٦	٤,١٤	٠,٠٧٥٤	٩,٠٥	٠,٠٠٦٥	٢٠,٠	٠,٠٠١٣٠	٠,٠٠٨٤٩
١٠,٤	١٧,٤	٣٤,٢٥	٤,٢٥	٠,٠٧٧٥	١٠,١٠	٠,٠٠٢١	١٧,٩	٠,٠٠٠٤٧	٠,٠٠٨٩٦
١١,٣	١٦,٠	٣٣,١١	٤,٣٩	٠,٠٨٠٠	١٠,٨٥	٠,٠٠٢٥	١٦,٧	٠,٠٠٠٦٠	٠,٠٠٩٥٦
١٢,٥	١٤,٥	٣٣,٩٥	٤,٥٥	٠,٠٨٢٩	١١,٩٠	٠,٠٠٢٩	١٥,٢	٠,٠٠٠٧٦	٠,٠١٠٣٢
١٣,٠	١٣,٩	٣٣,٨٧	٤,٦٣	٠,٠٨٤٤	١٢,٧٥	٠,٠٠١٥	١٤,٢	٠,٠٠٠٤٢	٠,٠١٠٧٤
١٣,٥	١٣,٤	٣٣,٨٢	٤,٦٨	٠,٠٨٥٢	١٣,٢٥	٠,٠٠٠٨	١٣,٧	٠,٠٠٠٢٣	٠,٠١٠٩٧
١٣,٧	١٣,٢	٣٣,٧٨	٤,٧٢	٠,٠٨٥٩	١٣,٦٠	٠,٠٠٠٧	١٣,٣	٠,٠٠٠٢١	٠,٠١١١٨
٢٨٠	٠,٦٥	٣٥,٧٩	٠	٠	٠	٠	٠	٠	٠
٣٣١	٠,٥٥	٣٥,٥٦	٤,٩٥	٠,٠٩٠١	١٧٢,٤	٠,٠٠٤٢	١,٠٥	٠,٠١٦٠٠	٠,٠٢٧١٨
٤٧٧	٠,٣٨	٣٥,٠٠	٥,٥١	٠,١٠٠٤	٤٠٤,٠	٠,٠١٠٣	٠,٤٥	٠,٠٩١٥٦	٠,١١٨٧٤
٧٧٠	٠,٢٣	٣٤,٢٥	٦,٢٦	٠,١١٣٩	٦٢٣,٥	٠,٠١٣٥	٠,٢٩	٠,١٨٦٢١	٠,٣٠٤٩٥
١٢٠٠	٠,١٥	٣٣,٣٦	٧,١٥	٠,١٣٠١	٥٨٥,٠	٠,٠١٦٢	٠,١٨	٠,٣٦٠٠٠	٠,٦٦٤٩٥
٢١٦٠	٠,٠٨	٣٢,٤٨	٨,٠٣	٠,١٤٦٢	١٦٨٠,٠	٠,٠١٠١	٠,١١	٠,٥٨٥٤٥	١,٢٥٠٤٠
٤٣١٢	٠,٠٤	٣٢,١٧	٨,٣٤	٠,١٥١٩	٣٢٣٦,٠	٠,٠٠٥٧	٠,٠٦	٠,٣٨٠٠٠	١,٦٣٠٤٠
٨٢١٧	٠,٠٢	٣٢,٣	٨,٤٨	٠,١٥٤٤	٦٢٦٤,٥	٠,٠٠٢٥	٠,٠٣	٠,٣٣٣٣٣	١,٩٦٣٧٣
١٠٦٢٨	٠,٠٢	٣١,٩٦	٨,٥٥	٠,١٥٥٨	٩٤٢٢,٥	٠,٠٠١٤	٠,٠٢	٠,٢٨٠٠٠	٢,٢٤٣٧٣
١١٥٨٠	٠,٠١	٣١,٩٣	٨,٥٨	٠,١٥٦٣	١١١٠٤,٠	٠,٠٠٠٥	٠,٠٢	٠,١٠٠٠٠	٢,٣٤٣٧٣

Table (4) The porosity parameter for the three different types of positive active method

Type of PbO_2	pore volume (cc/g)	Pore area (m^2/g)	Median pore diameter : µm
paste positive	0.1868	2.6654	0.15
cured positive	0.0329	0.537626	0.04
uncured positive	0.1563	2.34373	0.15

Table (5) The data of pore size distributions for the three types of positive active method

paste positive		cured positive		uncured positive	
D	ΔV \ ΔD	D	ΔV \ ΔD	D	ΔV \ ΔD
١٠٠,٤٨٣	0.0001542	١٥٧,٢٧٨	0.0000063	١٥٧,٣	0.0000158
٦٥,٧٧٠	0.00058767	٩٠,٤٣٥	0.0000293	٩٥,٢	0.0000138
٥٢,٤٢٦	0.0017985	٦٤,٥٩٦	0.0002128	٦٥,٨	0.0003639
٤٢,٠٦٢	0.00262446	٤٦,٣٧٦	0.0002854	٤٧,٦	0.0007197
٣٤,١٢٦	0.0013482	٣٣,٨٠٧	0.00030223	٣٦,٢	0.00185
٢٩,٤٠٩	0.00224719	٢٦,٧٩٥	0.0002281	٢٩,٢	0.0013
٢٥,٤٧٤	0.0022363	٢٢,٠٥٧	0.00005065	٢٤,٠	0.001769
٢٢,١٩٢	0.0012175	١٨,٩٣٩	0.0002565	٢٠,٠	0.001625
٢٠,٠٩٦	0.0018706	١٧,٢٢٥	0.0004084	١٧,٩	0.001
١٧,٥٦٠	0.00063091	١٥,٩٣٥	0.0005426	١٦,٧	0.002083
١٥,٩٣٥	0.00110769	١٥,٠٠٩	0.0005399	١٥,٢	0.001933
١٤,٥٢٧	0.0056818	١٤,١٣٠	0.00005688	١٤,٢	0.0015
١٣,٧٠٢	0.00084848	١٣,٥٤٨	0.0005154	١٣,٧	0.004
١٣,٢٩٩	0.00099255	١٣,٢٩٩	0.001204	١٣,٣	0.00175
٠,٤٥٧٣	0.01836	١٣,٠١٢	0.002439	١,٠٥	0.004
٠,٢٦٤	0.04345	٠,٤٦٣	0.000647	٠,٤٥	0.017166
٠,١٥٤	0.11454	٠,٣٤٤	0.0036134	٠,٢٩	0.08437
٠,٠٩٤٢	0.21571	٠,٢٠١	0.007692	٠,١٨	0.14727
٠,٠٥٧٧	0.21095	٠,٠٥٥	0.006164	٠,١١	0.14428
٠,٠٣٩٠	0.12834	٠,٠٦٩	-0.1	٠,٠٦	0.114
٠,٠٢٧٧	0.15929	٠,٠٤٩	0.07	٠,٠٣	0.0833
٠,٠٢٠٥	0.15277	٠,٠٣٣	0.05625	٠,٠٢	0.14
٠,٠١٧٠	000	٠,٠٢٢	0.04545	٠,٠٢	0.000
٠,٠١٤٩	0.19047	٠,٠١٨	0.05		
٠,٠١٣٥	0.21428				
٠,٠١٢٧	0.25				
٠,٠٢٢	0.02150				

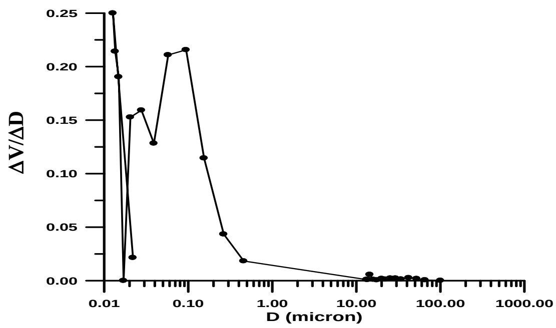

Fig (1) Pore volume distribution over pore diameter for paste positive

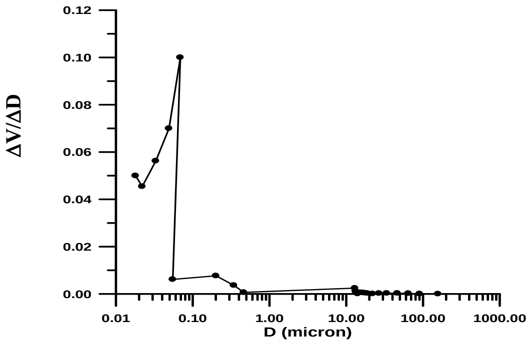

Fig (2) Pore volume distribution over pore diameter for cured positive

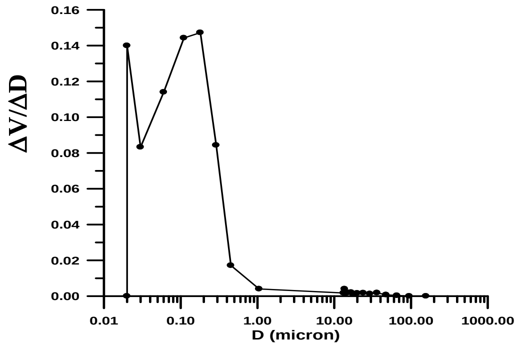

Fig (3) Pore volume distribution over pore diameter for uncured positive

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قياسات المسامية لألواح نضيدة الرصاص الموجبة بطريقة مقياس المسامية الزئبقية

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الخلاصة :

تم استخدام جهاز المسام الزئبقي لقياس حجم الداخلي لثلاثة أنواع ألواح نضيدة الرصاص الحامضية الموجبة ، تم حساب قطر المسام، حجم المسام ، مساحة المسام ، وتوزيع حجم المسام من خلال الحجوم الداخلة . أن الاختلاف في مساحة المسام لألواح نضيدة الرصاص الحامضية الموجبة وكذلك حجم المسام تتبع الترتيب الأتي

paste positive > uncured positive > cured positive