



–

- Nanocapillary

1

μ

MIS 375233

μ (1) μ 3 (. . 3),
 μ μ 3 μ .
 , (1) μ μ μ
 Vycor 7930, (2) μ μ Vycor μ
 μ μ
 - . (3) μ 2 μ
 μ μ μ μ - .
 μ μ
 (μ μ μ) μ
 μ μ /SAXS
 /SAXS μ μ (Vycor),
 (MCM-41 SBA-15).

. . 3 Nanocapillary -
 , μ 1 ,
 2014.

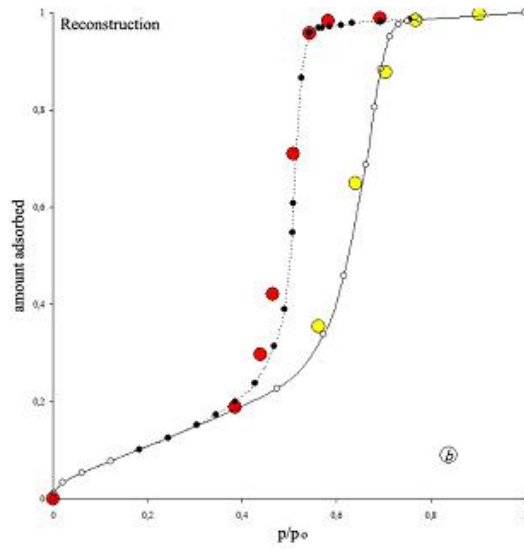
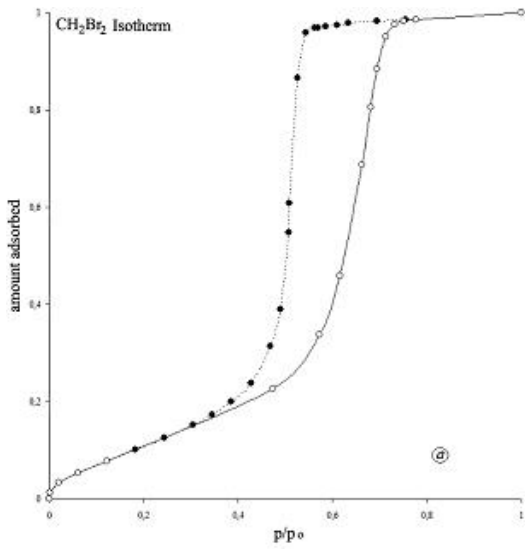
1

μ -1 (μ 1) μ Vycor μ
 μ CH₂Br₂ . CH₂Br₂
 μ μ μ
 (contrast matching). μ
 (scanning) μ μ . μ
 μ μ
 μ μ μ μ -

1 μ Vycor. μ μ
 μ , μ μ
 μ Vycor® 7930 μ
 μ μ μ SAXS (μ μ
 μ μ H₂O₂, μ μ).
 μ μ μ μ . μ
 μ μ μ μ ,
 μ (powder) ,
 μ μ μ
 μ μ μ
 (MCM-41 SBA-15).

μ IGA

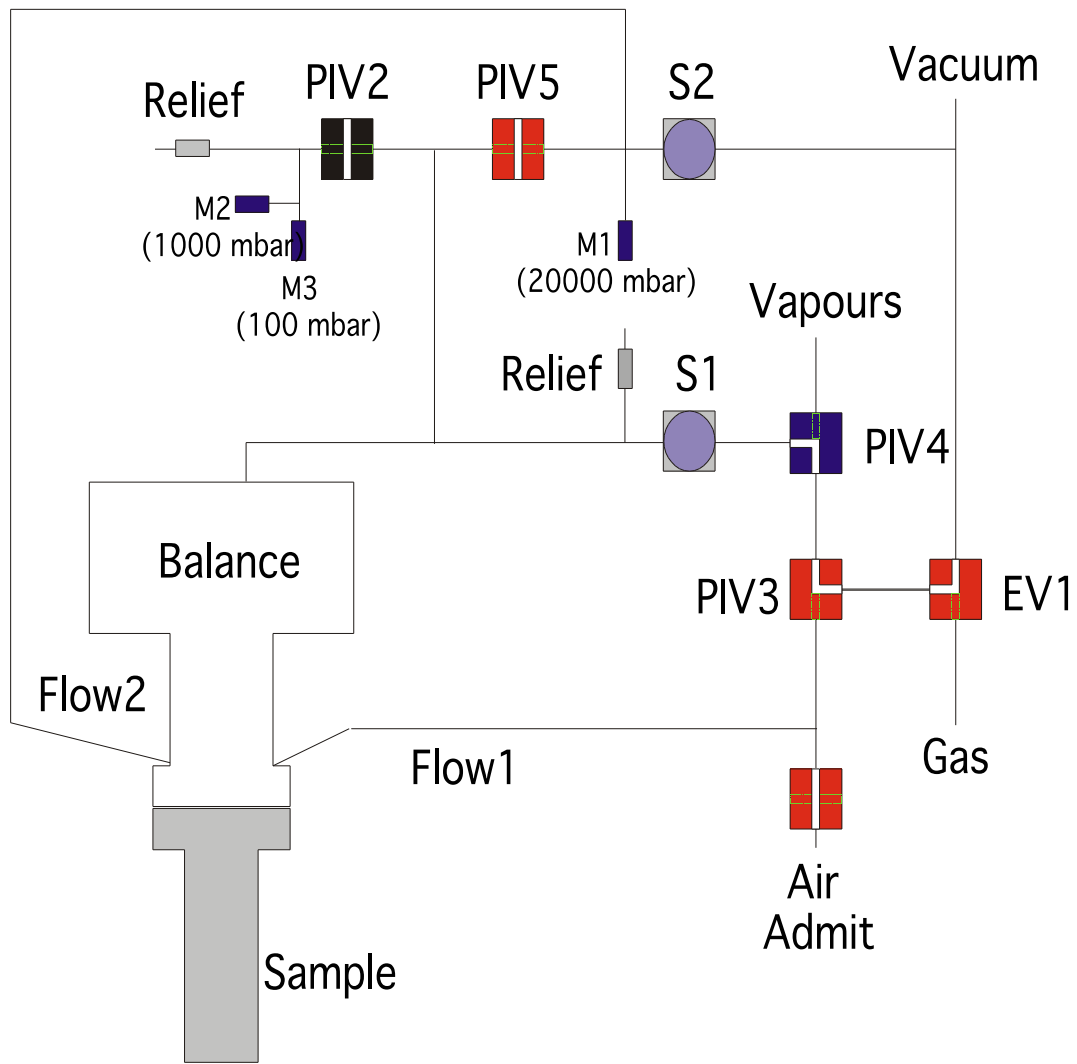
“ ” μ CH₂Br₂
 μ Vycor® 7930 μ ,
 μ , CH₂Br₂,
 μ , Vycor® 7930
 μ 10 mm , μ μ
 μ μ
 (Intelligent Gravimetric Analyser, IGA).



μ 3. () I μ CH_2Br_2 Vycor[®] 7930 ()
 μ μ μ - μ .

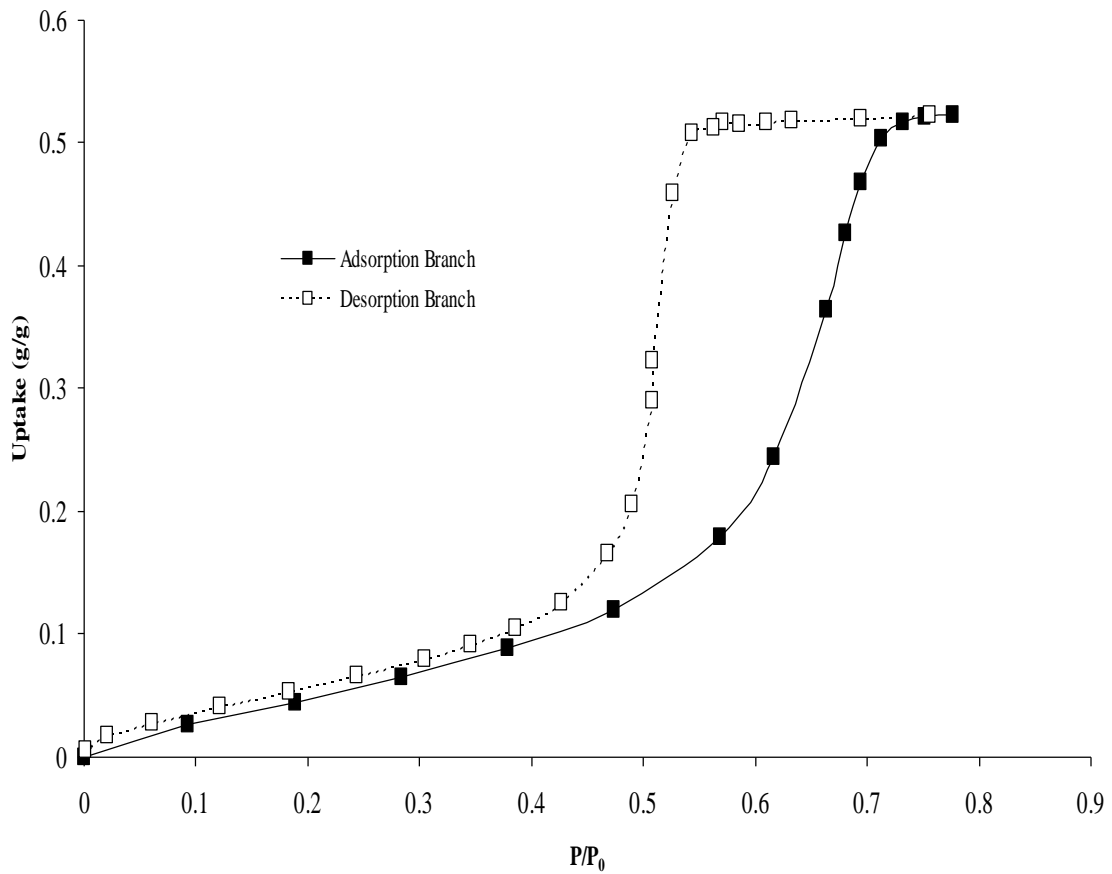
μ μ μ μ μ
 μ μ μ μ μ
 μ CH_2Br_2 () μ
 μ Adsorption (. . .6).

μ μ μ μ μ μ CH_2Br_2
 μ 20 C Vycor 7930. To μ
 μ μ μ (IGA-001
 HIDEN) μ / ,
 :



μ 4. μ μ μ (IGA).
 -He, - 2, - μ , -Manifold (μ μ), Cal.-Calibration
 (μ), - , - μ , V-
 (Pirani), P- , 0- μ .
 μ 4 μ μ
 (± 0.1 ~g), μ 0.1, 1 20 bar
 , μ μ μ μ μ
 . μ
 μ μ μ μ

(Vacumbrand MZ-2D) μ μ μ (turbo molecular –
 PFEIFFER TMU 60) μ μ
 / μ μ . ο μ
 12-24 h 120 C (10⁻⁷ mbar).
 μ CH₂Br₂ Vycor 20 C μ 2.
 μ μ μ IUPAC (International Union of Pure and Applied
 Chemistry), μ IV. μ μ
 p/p₀~0.5 μ
 p/p₀>0.7. H₂
 μ μ μ
 (μ , network effect).



μ 5. μ CH₂Br₂ Vycor 7930 20 C.

μ 5 μ μ Vycor.

μ SAXS

μ 1 “ ” μ

CH₂Br₂ μ Vycor[®] 7930. CH₂Br₂

μ μ μ

(contrast matching).

(scanning) μ

μ μ

μ μ μ ,

μ μ μ

μ μ , μ μ *in situ*

μ .

μ μ μ

μ . μ 1 (μ β_(a))

μ μ *in situ* μ SAXS 2

μ , μ CH₂Br₂

Vycor[®] 7930 μ μ μ (IGA). μ IV

2. μ

μ μ μ μ

μ μ μ

.

μ μ μ

μ , μ

μ μ

$$\ln\left(\frac{P}{P_0}\right) = \frac{K}{t^m} \ln(p/p_0) = K/t^m,$$
 Hasley

$$K=61.8 \quad m=2.219^4.$$

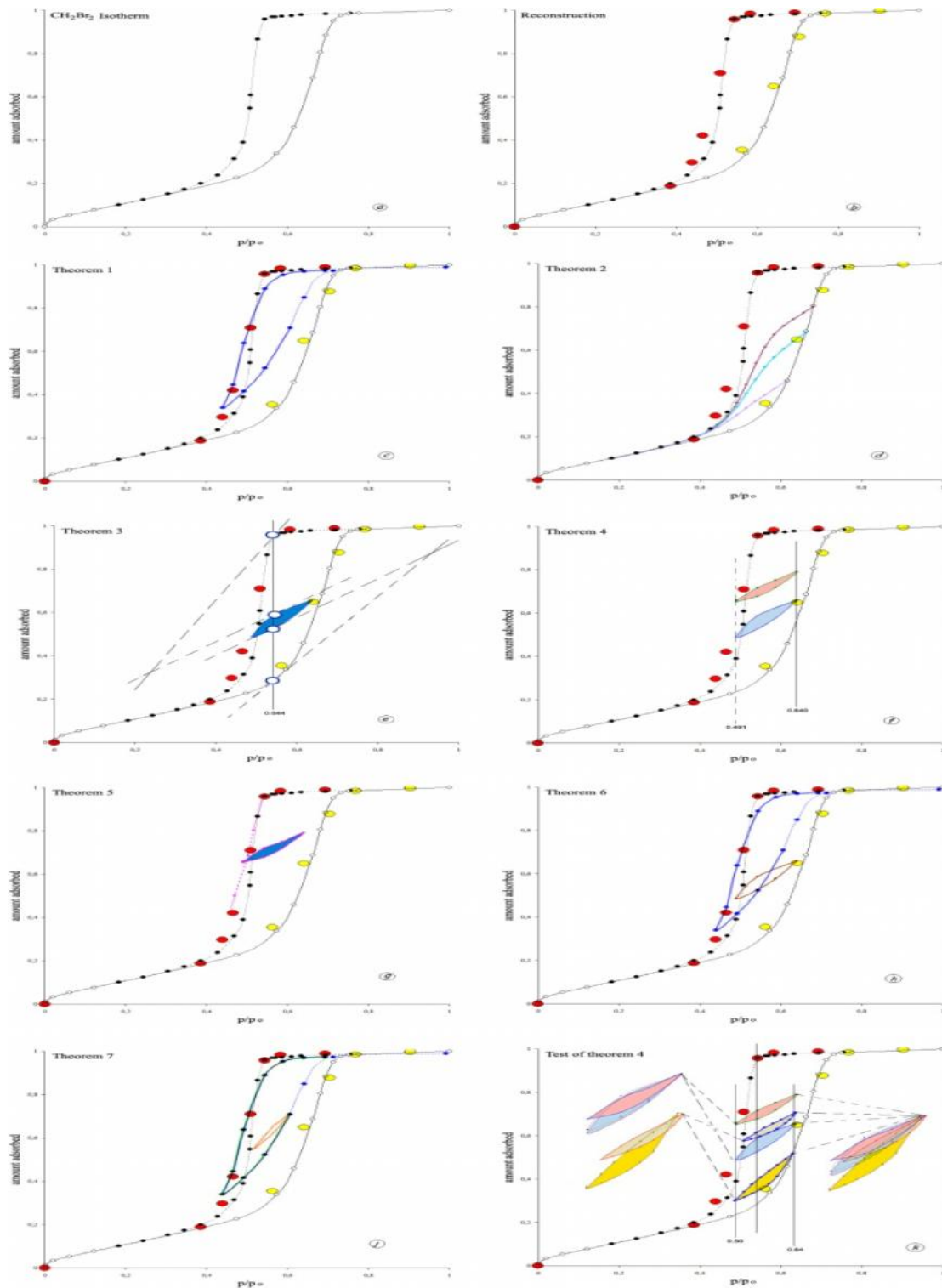
¹ D.H. Everett, D.W.I. Whitton, Trans. Faraday Soc., 48 (1952) 749.

² D.H. Everett, F.W. Smith, Trans. Faraday Soc. 50 (1954) 187.

³ D.H. Everett, Trans. Faraday Soc. 50 (1954) 1077.

⁴ A.Ch. Mitropoulos, J. Coll. Interface Sci. 336 (2009) 679.





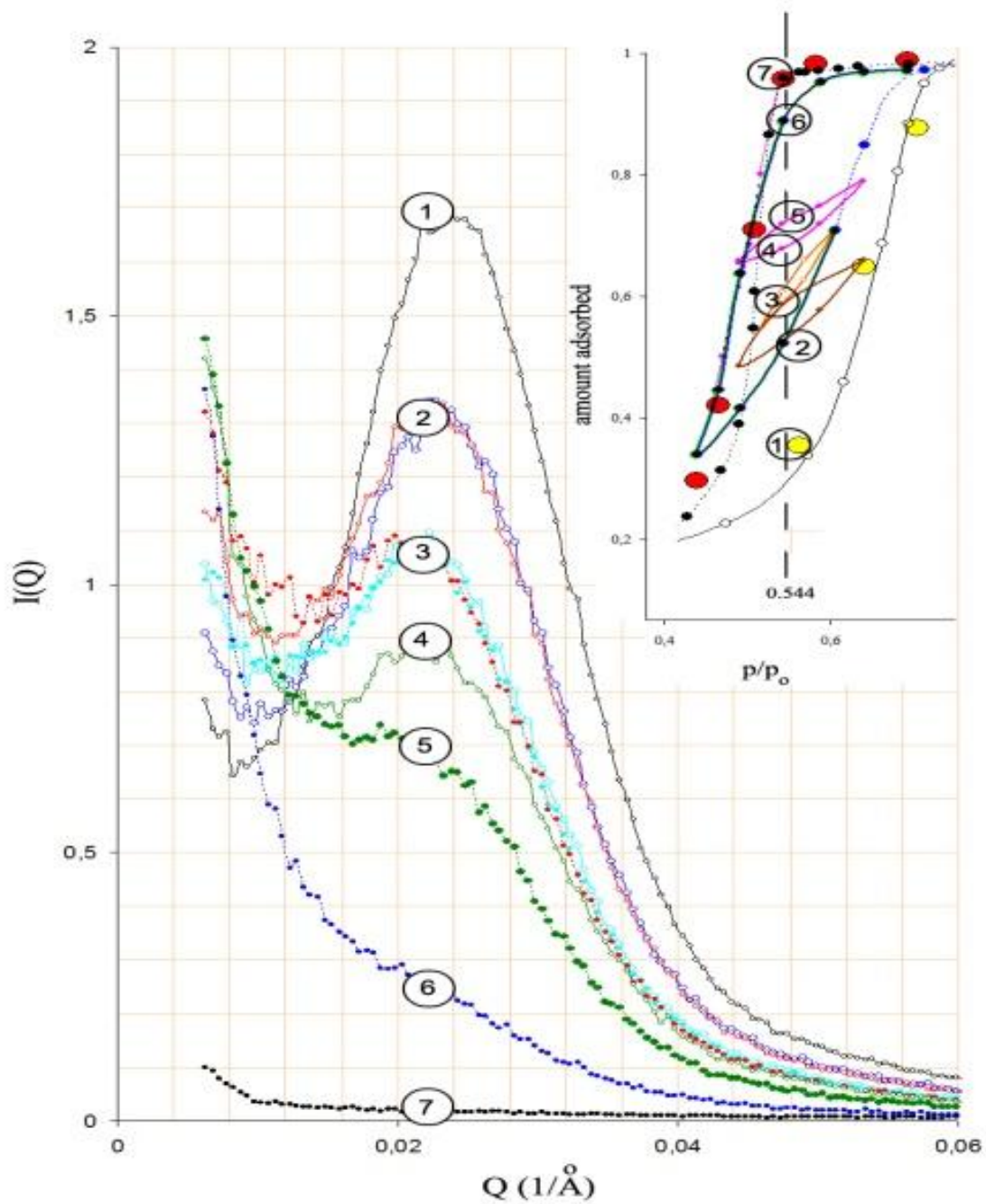
μ 6. μ CH_2Br_2 Vycor[®] 7930 (a). μ μ
 μ SAXS (b).
 1 2 μ Everett (c), (d). (e)
 3 μ μ (f)
 (k) μ μ 4 μ 5' 6 7 μ
 (g), (h), (j).
 μ - μ (μ 7)
 μ μ CH_2Br_2
 Vycor[®] 7930.
 2. μ μ μ
 μ μ μ .
 μ μ μ
 μ , μ ,
 μ μ Prof. Everett^{5,6,7}
 μ μ μ 1 μ (*t-film*)
 μ Hasley $\ln\left(\frac{P}{P_0}\right) = \frac{K}{t^m} \ln(p/p_0) = K/t^m$,
 m μ μ K=61.8 m=2.219⁸.

⁵ D.H. Everett, D.W.I. Whitton, Trans. Faraday Soc., 48 (1952) 749.

⁶ D.H. Everett, F.W. Smith, Trans. Faraday Soc. 50 (1954) 187.

⁷ D.H. Everett, Trans. Faraday Soc. 50 (1954) 1077.

⁸ A.Ch. Mitropoulos, J. Coll. Interface Sci. 336 (2009) 679.



μ 7. μ SAXS μ CH_2Br_2 Vycor®
 7930. μ μ “ μ ” μ μ
 . 2 3 μ

μ (μ SAXS) μ μ
 μ μ
 2 $P/P_0 = 0.544$, μ
 μ μ 3
 μ 1 μ 2
 μ CH₂Br₂ μ
 μ μ “μ μ” μ μ
 μ μ μ
 μ P/P_0 ,
 μ μ
 μ CH₂Br₂ μ 20 °C μ
 -X - μ CuKa
 2D Rigaku. μ Q
 0.005 – 0.15 Å⁻¹ ($Q=4 \sin /$ μ , μ 2
 μ μ).
 μ 7 μ IV μ 2
 μ μ μ μ
 μ μ μ
 μ μ μ

“ ” μ μ μ (CH₂Br₂)
 .
 μ μ μ
 () μ
 t-film μ .
 t-film “ ” μ :

$$\Delta(p) = (V_D - V_A) \left[\frac{(R - t(p))^2}{(R - t(pA))^2} - 1 \right]$$

t-film μ μ Hasley
 ln(p/p₀)=K/t^m, μ μ : K = 61.8 m = 2.219.

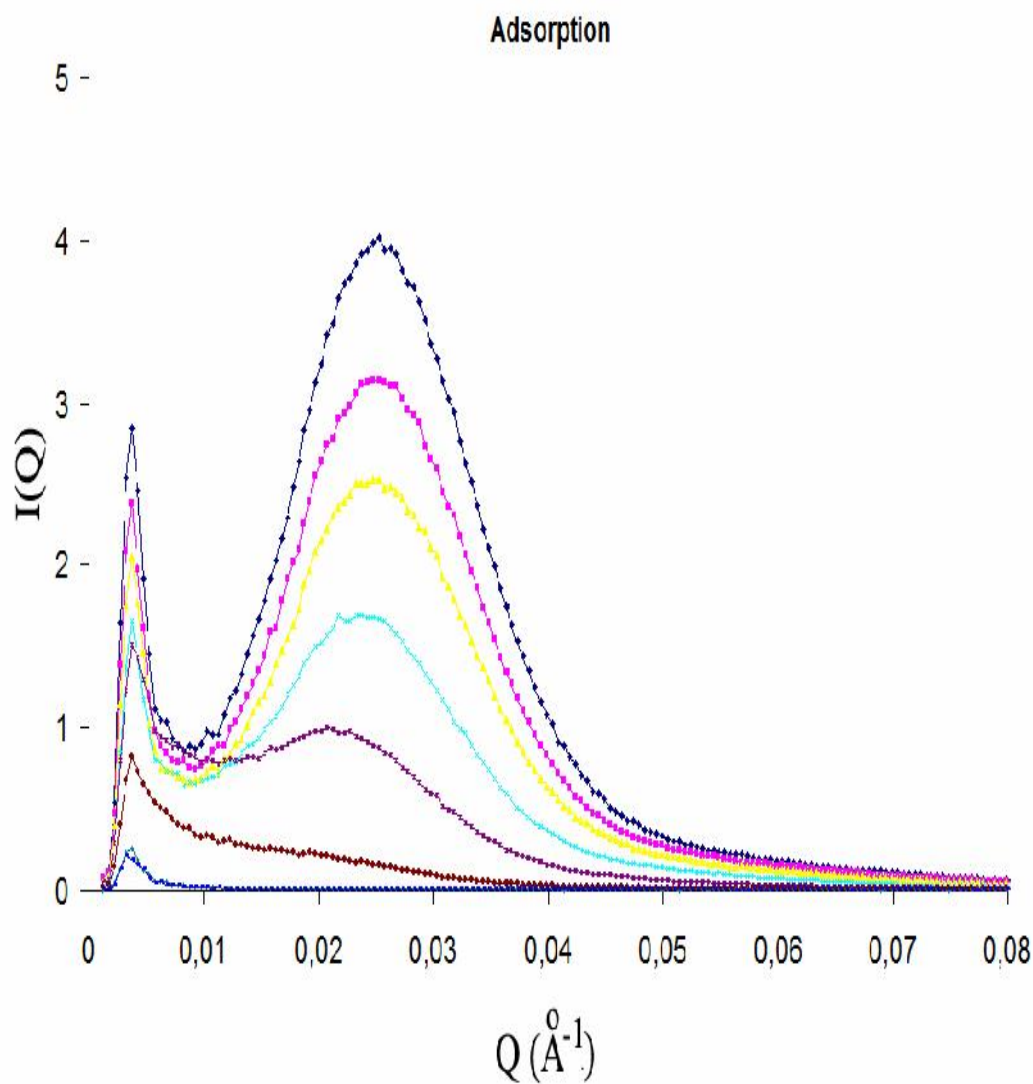
μ μ μ
 μ μ ,
 μ μ .
 μ fractal μ
 μ μ .

«Porod» μ . μ μ μ μ
 μ μ μ μ .
 () μ μ μ
 fractal μ μ μ μ
 μ μ 1 ,
 2 3 μ μμ .



μ μ (CH_2Br_2) μ μ - (SAXS) μ
 μ SBA-15 μ
 μ μ μ "Eighth
 International Symposium Effects of Surface Heterogeneity in Adsorption and
 Catalysis on Solids", ISSHAC-8 (<http://isshac.org>).

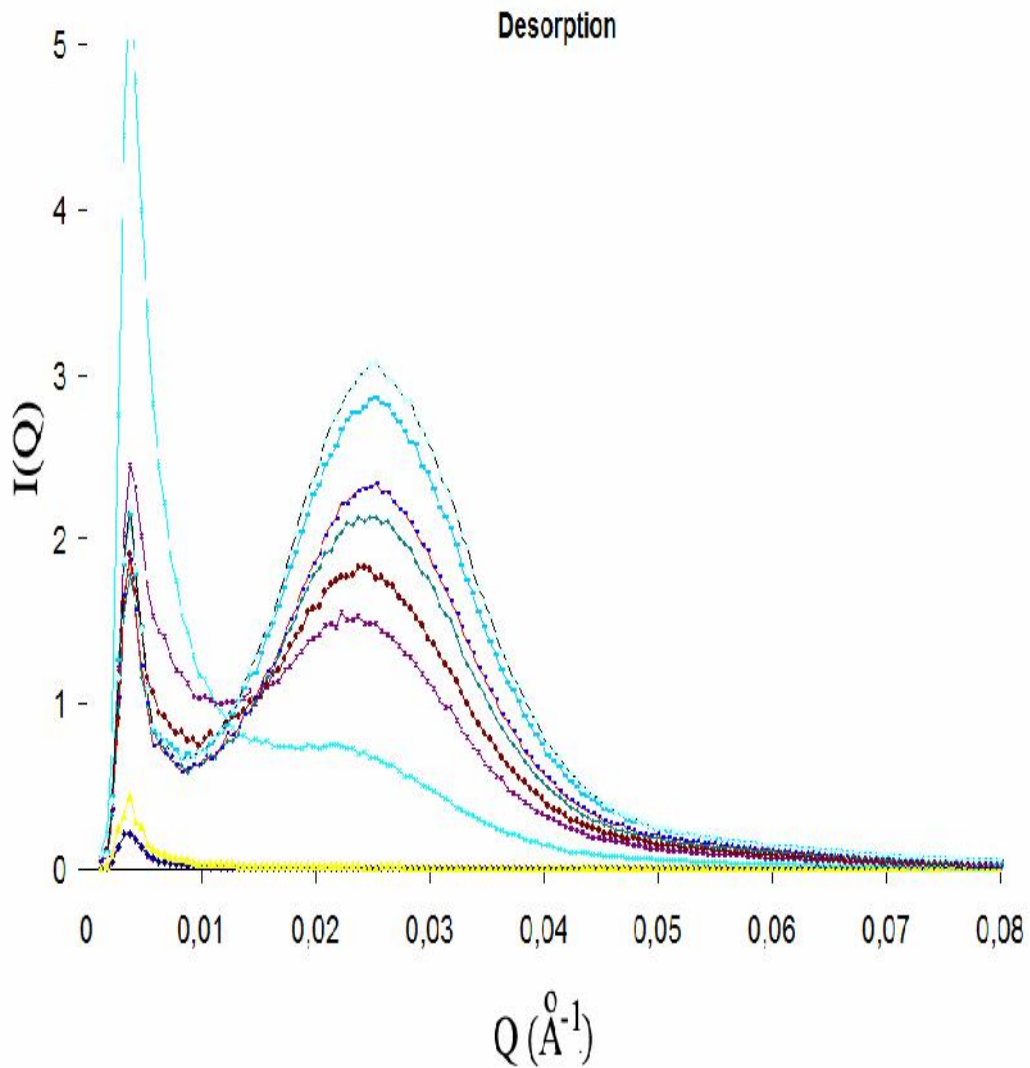
μ -x,
 , (in situ) μ SAXS
 - CH_2Br_2 20 C (μ 8 & 9).
 μ , μ $Q=0.0038 \text{ \AA}^{-1}$
 μ μ -x (beam stop),



μ 8. μ

Vycor
20 C.

CH_2Br_2



μ 9. μ Vycor CH_2Br_2
20 C.

μ (correlation peak)
Vycor μ $Q \sim 0.025 \text{\AA}^{-1}$ μ
 μ μ μ μ
 μ μ μ Kelvin. μ
 μ Bragg .

$(\mu = 7)$ μ μ
 Bragg. μ
 CH_2Br_2 μ (Vycor)
 μ μ
 μ (contrast matching).
 μ $(\mu = 8)$.
 μ μ μ μ ,
 μ μ μ $(\mu = 2)$
 μ μ .

1. J.M.Haynes and F.G.McCaffery, Light Scattering and Capillary Condensation in Porous Media, J.Coll.Interface Sci. 59 (1977) 24.