Chapter IV

EXPERIMENTAL RESULTS

4.1 Mass Transfer Rate

Due to the effect of systemic variables on mass transfer rate; effect of particle sizes, feed rates and concentrations of feed on mass transfer rate were studied.

4.1.1 Effect of Concentration of Solute

Fig 4.1a, 4.1b, 4.1c,4.1d 4.1e, 4.2, 4.2a, 4.3b and 4.4 represents uptake curves for adsorption of formaldehyde, sodium hydroxide, sodium carbonate and the mixture of sodium hydroxide and sodium carbonate in which the influent concentration of each solute was the only variable. It is observed that slopes of these nine curves, mass transfer rate M (See sample of calculation) increased with the increasing of the initial concentration of the feed. Numerical results are shown in Table C-1, C-2, C-3, C-4 and plotted in Fig 4-13, 4-14, 4-15, 4-16.

4.1.2 Effect of Particle Sizes of Activated Carbon

Four different sizes of granular SGL type of Activated carbon were selected for adsorption of formaldehyde, sodium hydroxide, sodium carbonate and the mixture of sodium hydroxide and sodium carbonate at constant feed rates and concentrations.

The uptake v.s. time curves for those different particle sizes are shown in Fig 4.5, 4.6, 4.7, 4.8 for adsorption of formaldehyde, sodium hydroxide, sodium carbonate and the mixture of sodium hydroxide and sodium carbonate respectively. It is observed that the slopes of these four curves, mass transfer rate M, decreased with the increasing of the sizes of activated carbon. The results are shown in Table C-1, C-2, C-3, C-4 and Fig 4-17, 4-18, 4-19, 4-20.

4.1.3 Effect of Feed Rates

Fig 4.9, 4.10, 4.11 and 4.12 show cumulative uptake of formaldehyde, sodium hydroxide, sodium carbonate, mixture of sodium hydroxide and sodium carbonate by activated carbon as a function of time for different feed rates. About 100 gm of SGL type activated carbon was used for each operation. The effect of feed rate on mass transfer rate are presented in Table C-1, C-2, C-3, C-4 and Fig 4.21, 4.22, 4.23 and 4.24

It reveals that mass transfer rate is increased with feed rate.

4.2 Mass Transfer Coefficient

Weber (27) demonstrated for adsorption in fluidized bed that initial rate of uptake of solute would likely be controlled by the film transport at the external surface area of the adsorbent. This expectation has been verified by a demonstrated dependence of transfer rate on flow rate over the entire range of flow rates investigated. Intraparticle transport in such low velocity flow through systems should enter as a rate controlling mechanism only in later stages of column operation.

Based on the assumption of film transport, a relatively simple rate relationship can be set forth for the initial stages of adsorption in the experimental fluidized carbon columns. If the quantity $(C_o - C)v/m_c$ is used to represent the uptake of solute per unit mass of adsorbent at any point in time, then the rate of transfer of solute from bulk solution to the adsorbent can be described by the expression

$$\frac{d}{dt}\left(\frac{(C_o - C)v}{m_c}\right) = k\,S\,(C - C^*) \qquad (4.1)$$

and then

$$\frac{dm}{dt} = \frac{d}{dt}\left(\frac{(C_o - C)v}{m_c}\right) = k\,S\,(C - C^*) \qquad (4.2)$$

Weber (27) pointed out that for fluidized operating in which adsorbent particles are, for all practical purpose, completely mixed over the length of the column, the value C^* should be uniform throughout the bed. The quantity C will of course vary logarithmically over the length of the column. However, during initial stages of operation, breakthrough of solute is negligible. For this condition the log-mean value for C^* varies very little and may be taken as an essentially constant multiple of C_o; consequently one may be substitute C_o for C in Eq (4.2) and include the constant multiplier in the mass transfer coefficient, k.

then $$\frac{dm}{dt} = kS(C_o - C^*) \qquad (4.3)$$

The concentration C* of solute at the solid surface side of the interfacial liquid film may be considered to be in equilibrium with the solid phase consideration of solute on the immediately available surface of the carbon particles. Hence, for all practical purposes the concentration C* of solute at the solid surface side of the interfacial film may be neglected for the initial stages of a run, during which the total uptake of solute is small in comparison to the saturation value. For this cases, Eq (4.3) reduces to

$$\frac{d}{dt}\left(\frac{(C_o - C)V}{m_c}\right) = \frac{dm}{dt} = k\ S\ Co \qquad (4.4)$$

4.2.1 Effect of Modified Reynolds Number

The modified Reynolds number of each experiment can be evaluated from

$$Re_p = \frac{d_p \cdot u_f \cdot \rho_f}{\mu_f}$$

and presented in Table C-1, C-2, C-3, C-4. The relation between Re_p and mass transfer coefficient calculated are also shown in Fig 4.25, 4.26, 4.27, 4.28. From graph the modified Reynolds number shows linear relation

4.2.2 Effect of Surface Area

Surface area of activated carbon can be evaluated from the relation of S and d_p by using the data selected from physical properties of activated carbon supplied by Pittsburgh Activated Carbon Co., Inc. (3) and the relations proposed by Dr. Phol (41). The results showing the relation between mass transfer coefficient and surface area illustrated in Table C-1, C-2, C-3, C-4 and in Fig 4.29, 4.30, 4.31 and 4.32 for adsorption of formaldehyde, sodium hydroxide, sodium carbonate and mixture of sodium hydroxide and sodium carbonate respectively. The results demonstrate a linear dependence of the mass transfer coefficient on the reciprocal of the surface area of activated carbon.

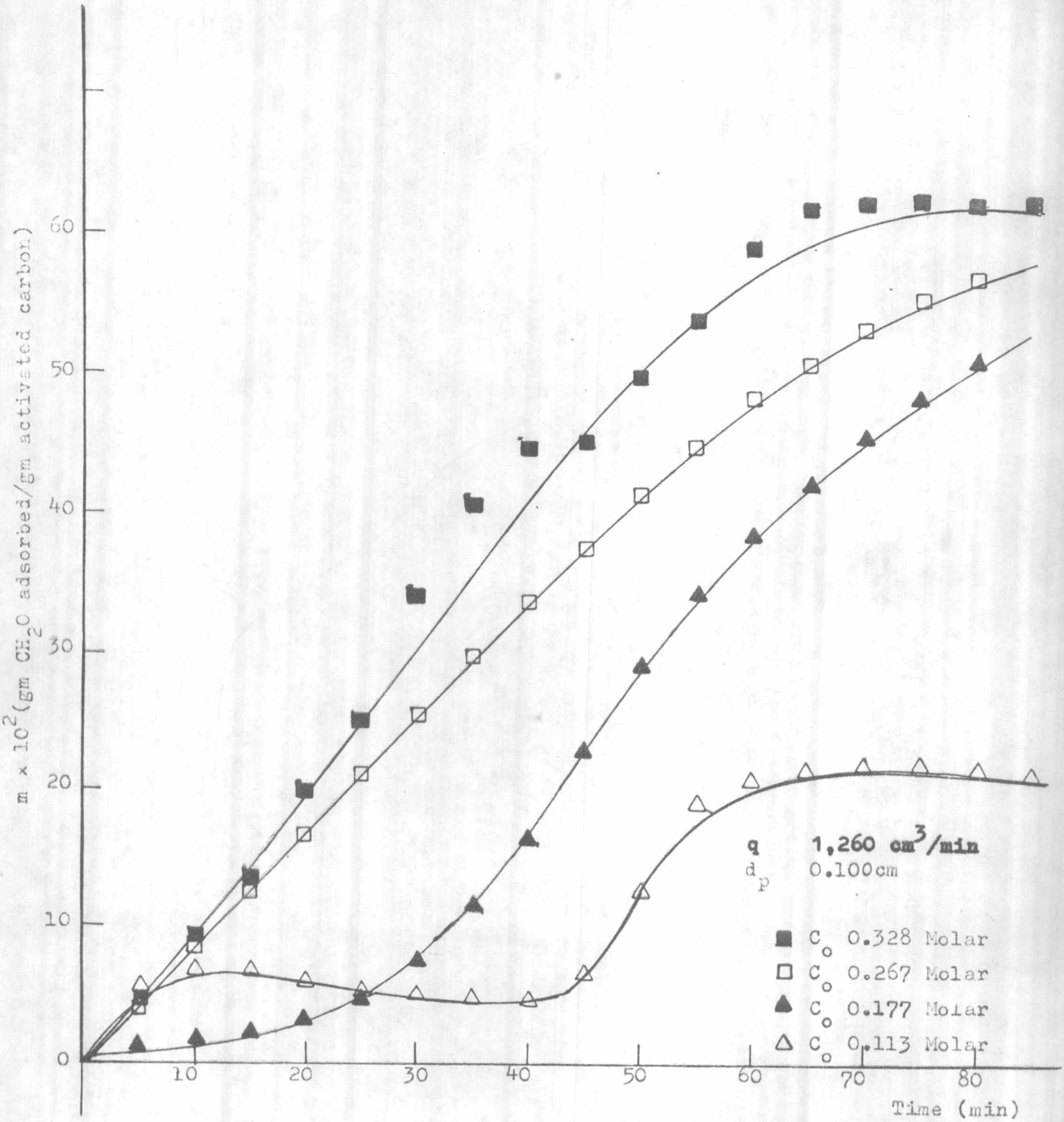

Fig. 4.1a Variation of Adsorptive Capacity (m) with Time (t) for Adsorption of Formaldehyde on Activated Carbon at Various Concentrations of the Feed.

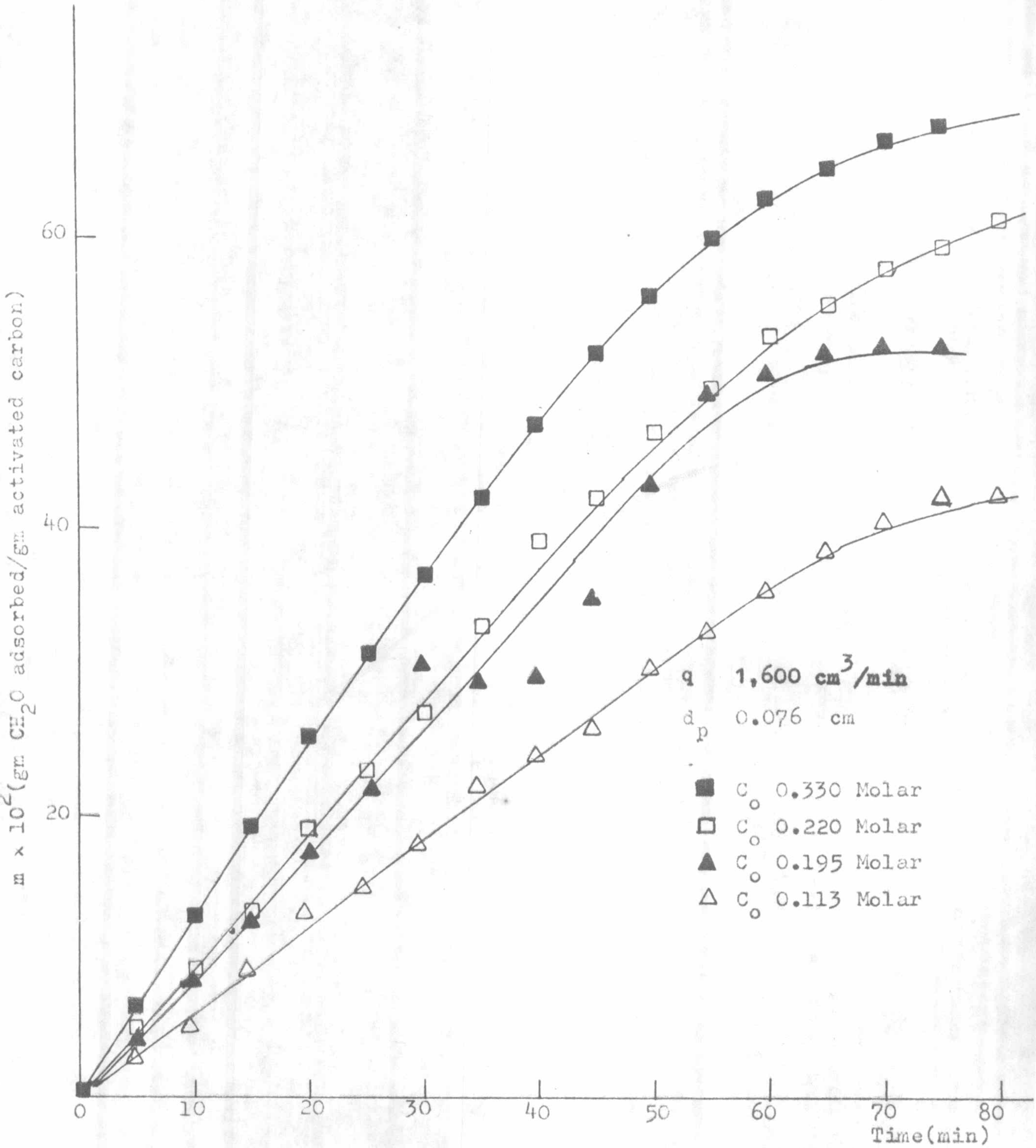

Fig. 4.1b Variation of Adsorptive Capacity (m) with Time (t) for Adsorption of Formaldehyde on Activated Carbon at Various Concentrations of the Feed.

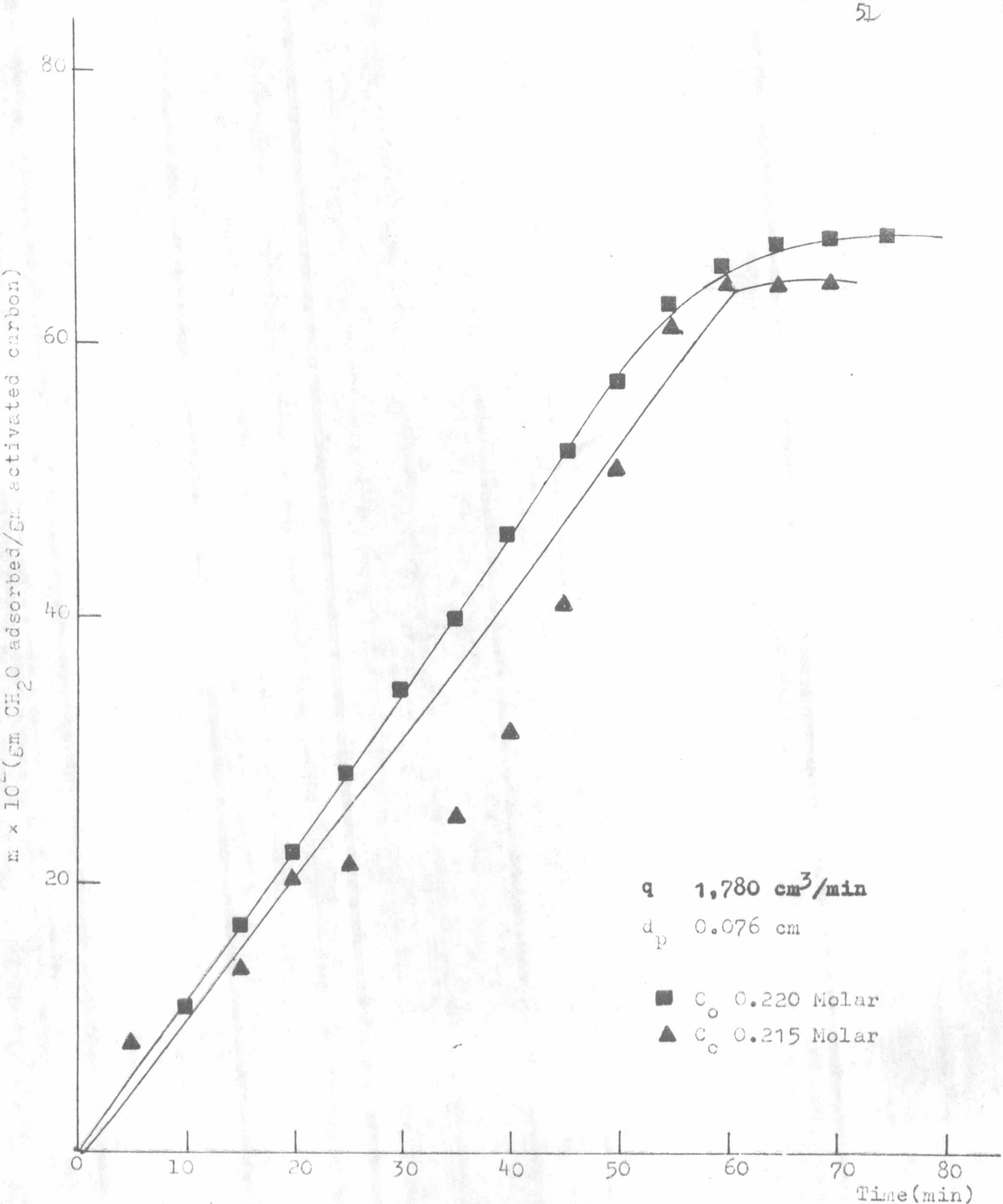

Fig. 4.1c Variation of Adsorptive Capacity (m) with Time (t) for Adsorption of Formaldehyde on Activated Carbon at Various Concentrations of the Feed

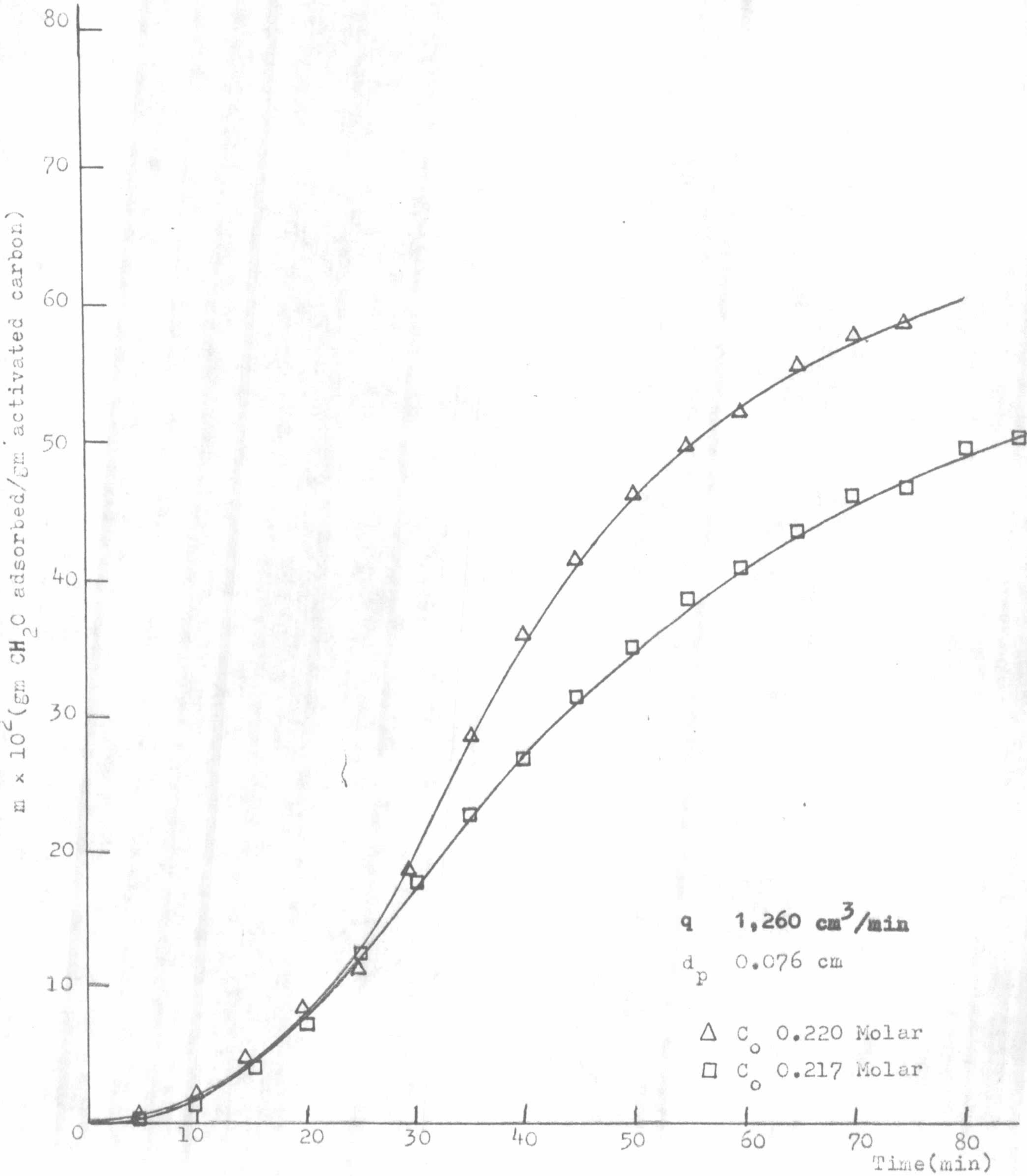

Fig. 4.1d Variation of Adsorptive Capacity (m) with Time (t) for Adsorption of Formaldehyde on Activated Carbon at Various Concentrations of the Feed.

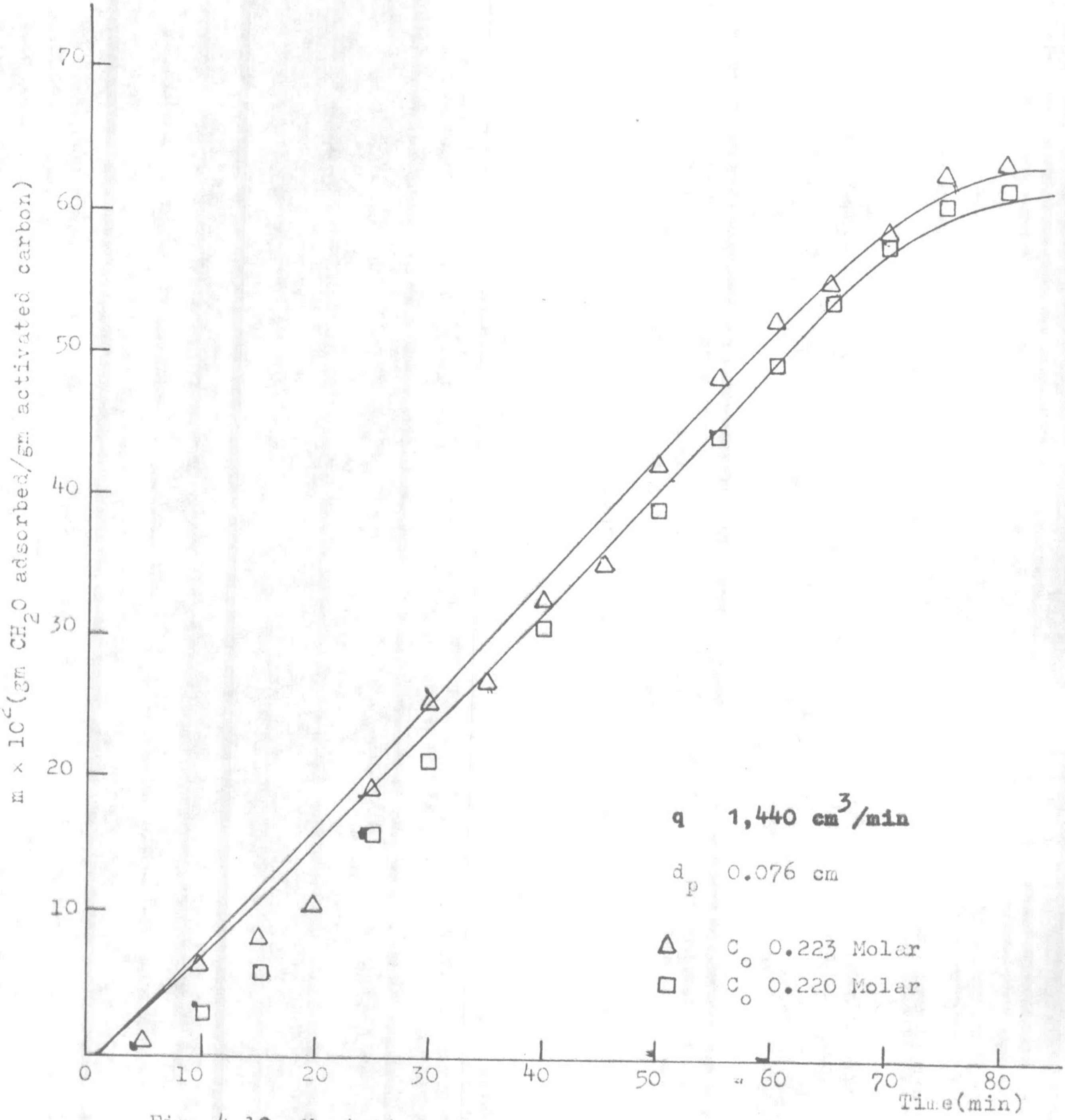

Fig. 4.1e Variation of Adsorptive Capacity (m) with Time (t) for Adsorption of Formaldehyde on Activated Carbon at Various Concentrations of the Feed.

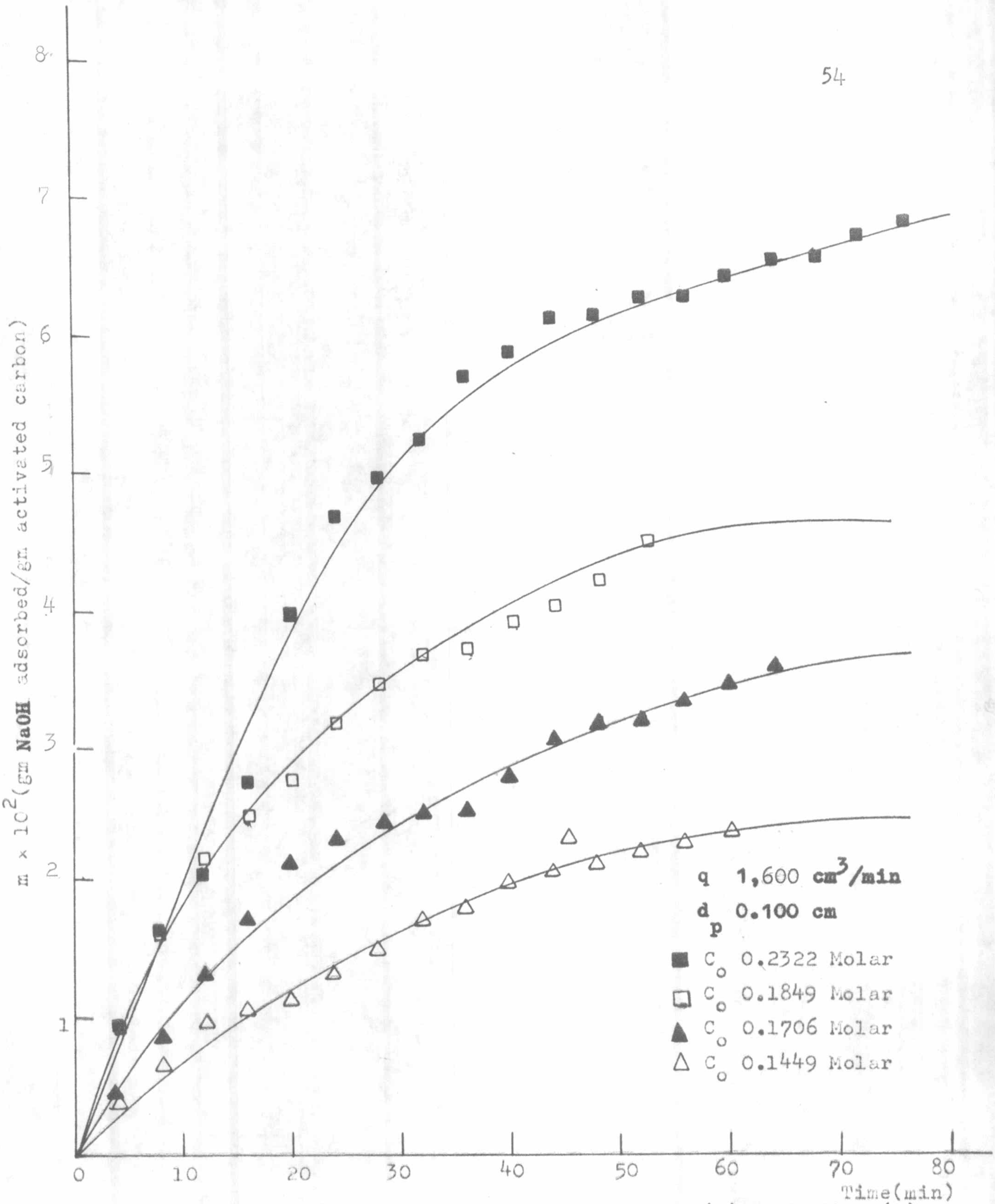

Fig. 4.2 Variation of Adsorptive Capacity (m) with Time (t) for Adsorption of **Sodium Hydroxide on Activated Carbon** at Various Concentrations of the Feed.

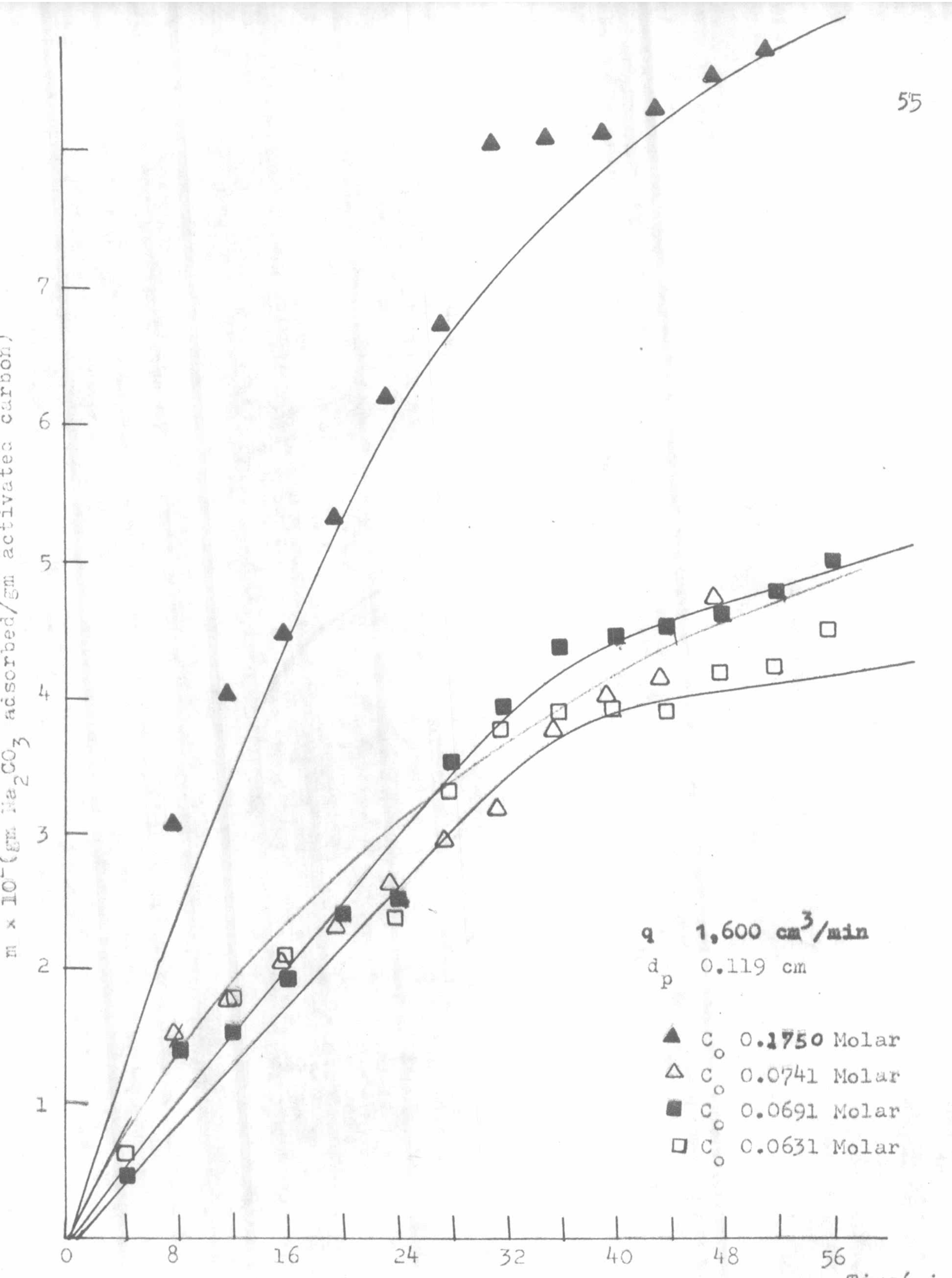

Fig. 4.3a Variation of Adsorptive Capacity (m) with Time (t) for Adsorption of Sodium Carbonate on Activated Carbon at Various Concentrations of the Feed.

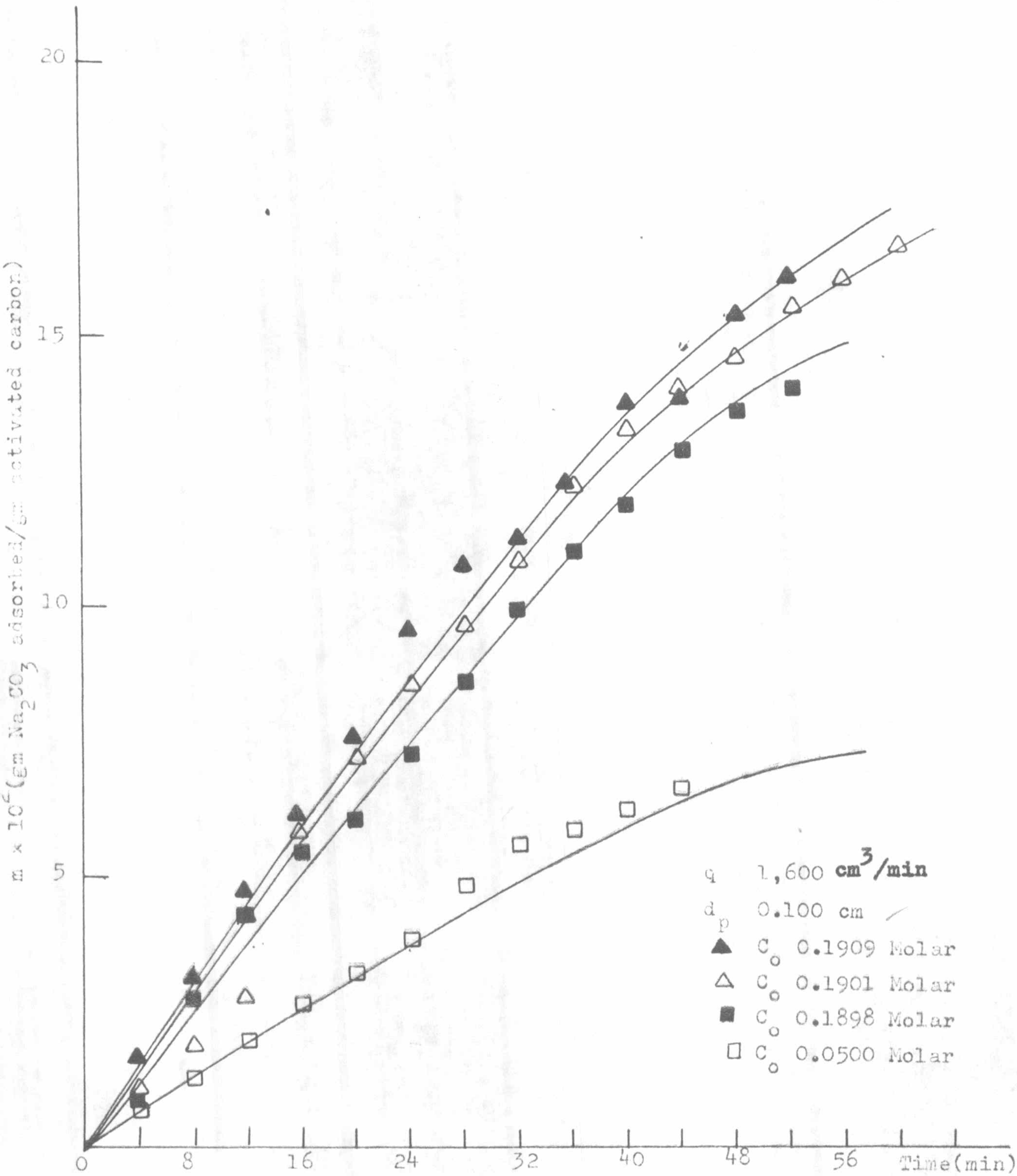

Fig. 4.3b Variation of Adsorptive Capacity (m) with Time (t) for Adsorption of Sodium Carbonate on Activated Carbon at Various Concentrations of the Feed.

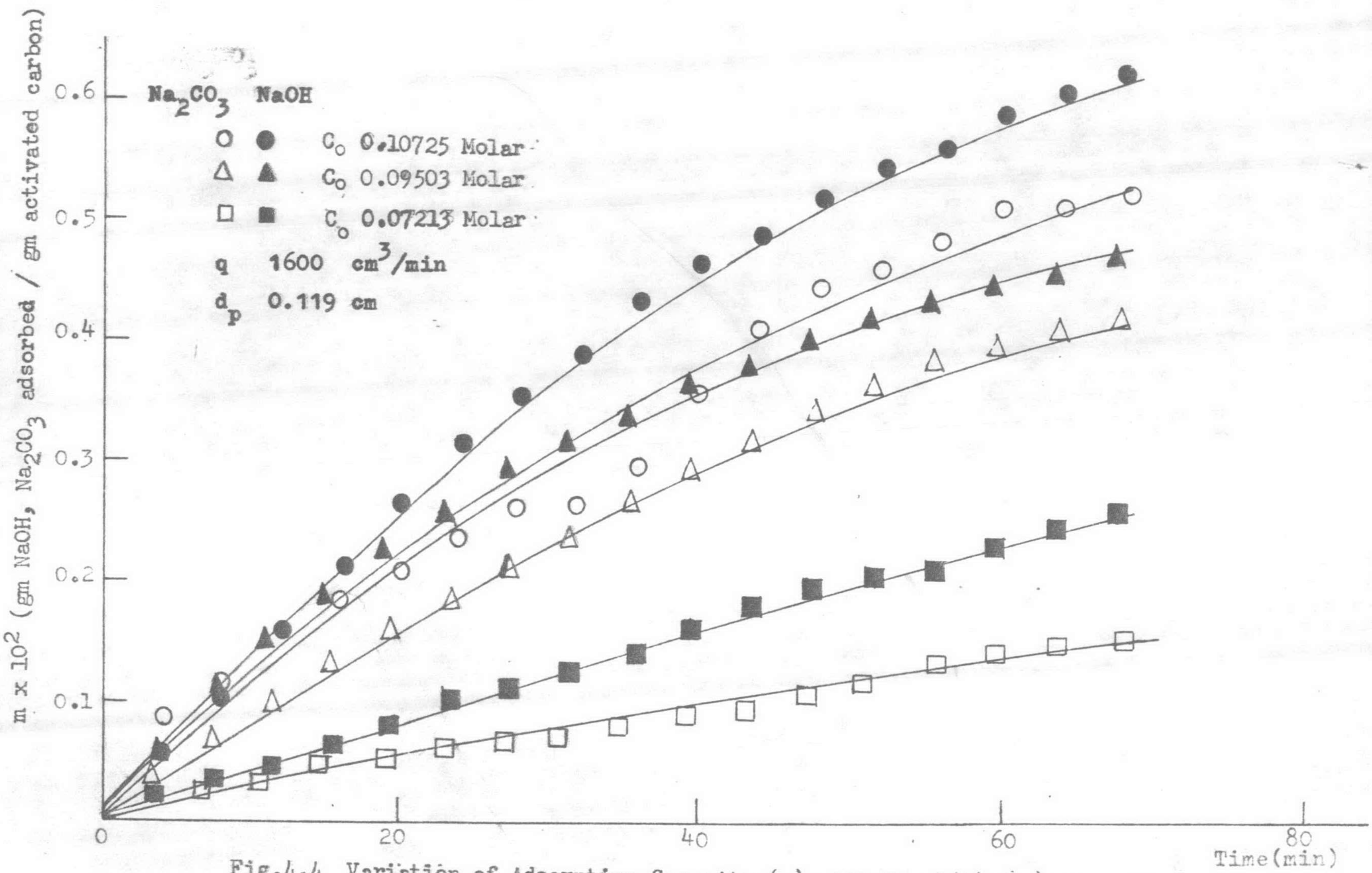

Fig.4.4 Variation of Adsorptive Capacity (m) with Time (t) for Adsorption of the Mixture of NaOH and Na_2CO_3 on Activated Carbon at Various Concentrations of Feed.

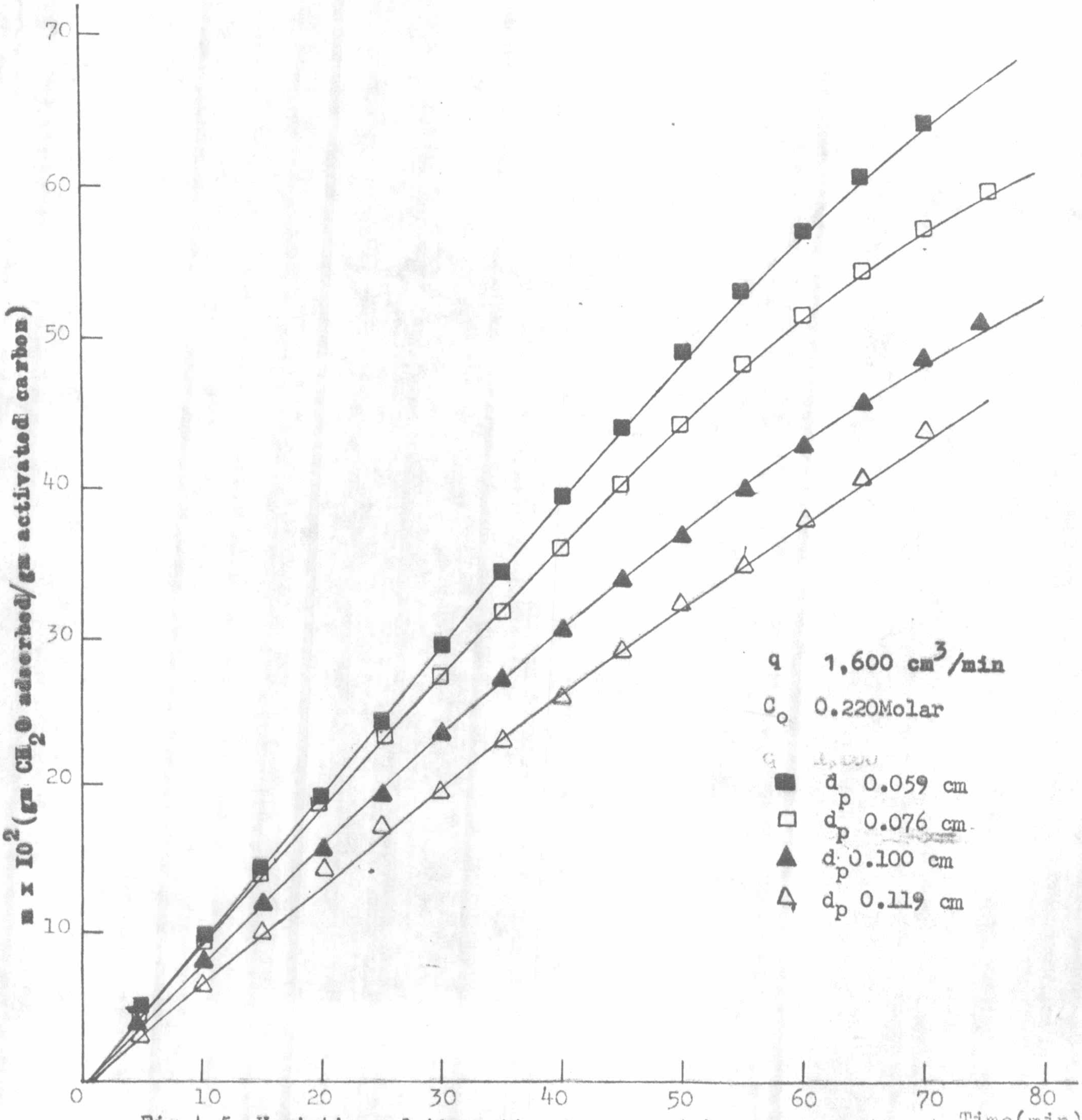

Fig.4.5 Variation of Adsorptive Capacity (m) with Time (t) for Adsorption of Formaldehyde on Activated Carbon at Various Sizes of Activated Carbon.

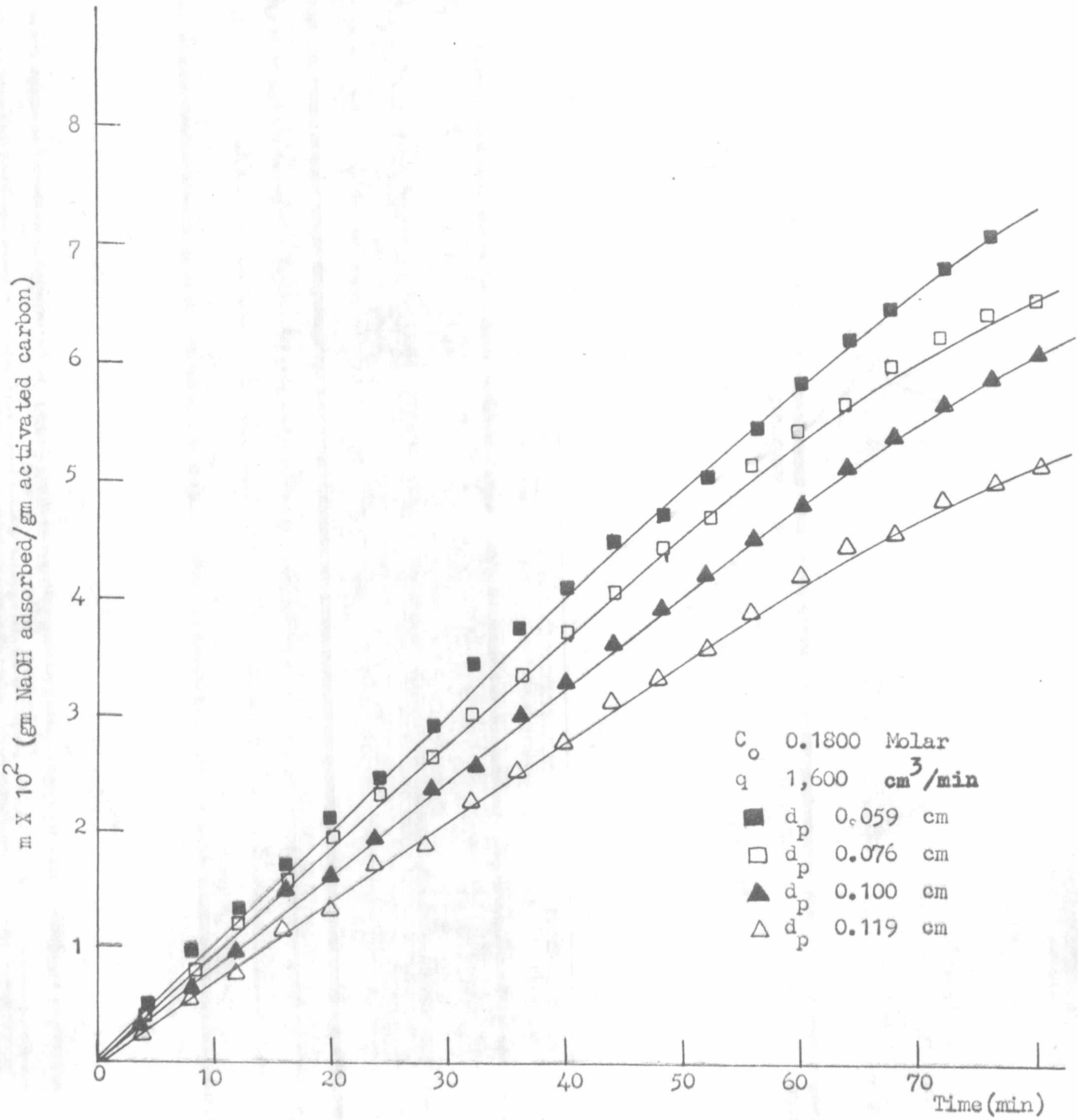

Fig.4.6 Variation of Adsorptive Capacity (m) with Time (t) for Adsorption of NaOH at Various Sizes of Activated Carbon.

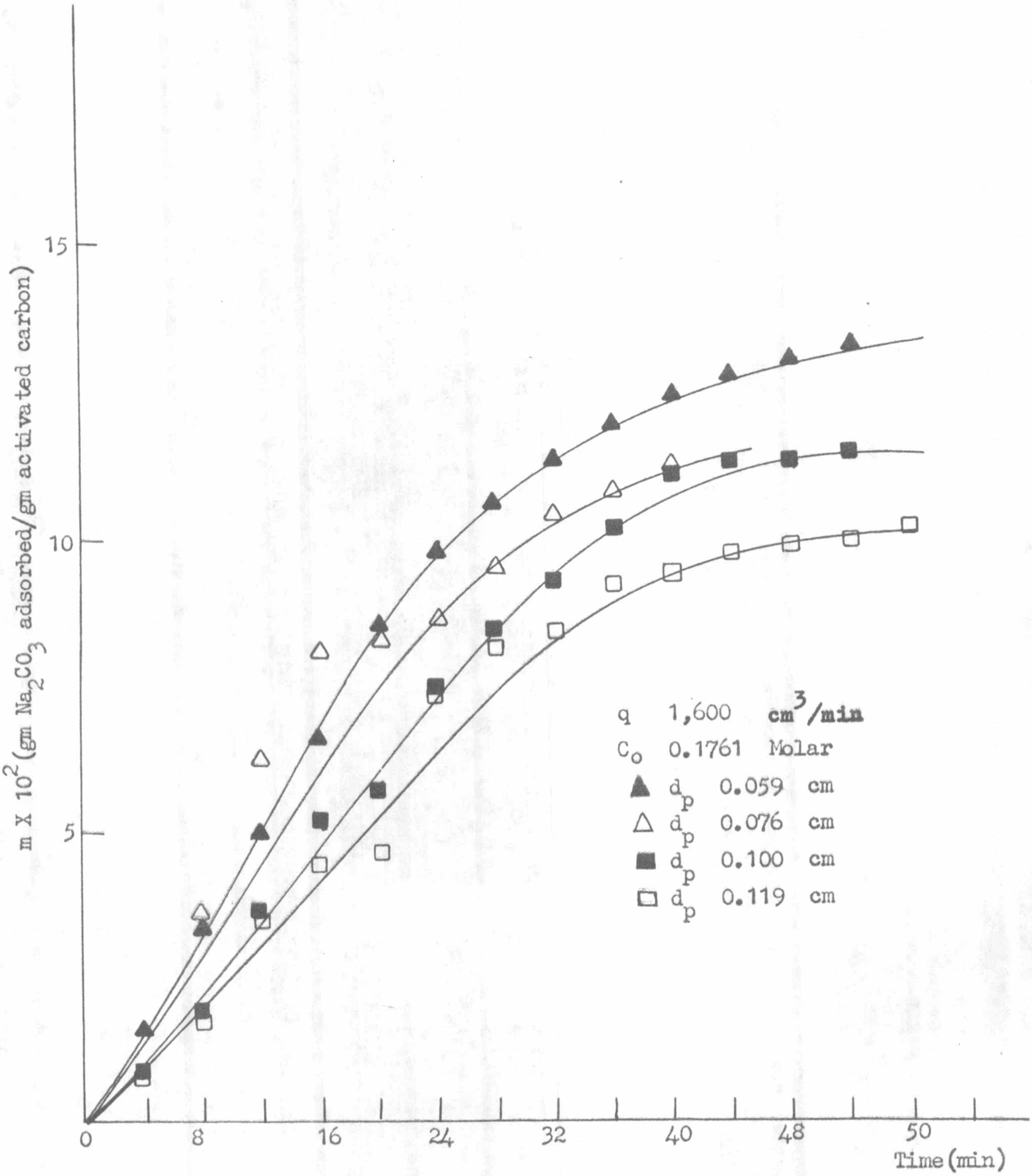

Fig.4.7 Variation of Adsorptive Capacity (m) with Time (t) for Adsorption of Sodium Carbonate on Activated Carbon at Various Sizes of Activated Carbon

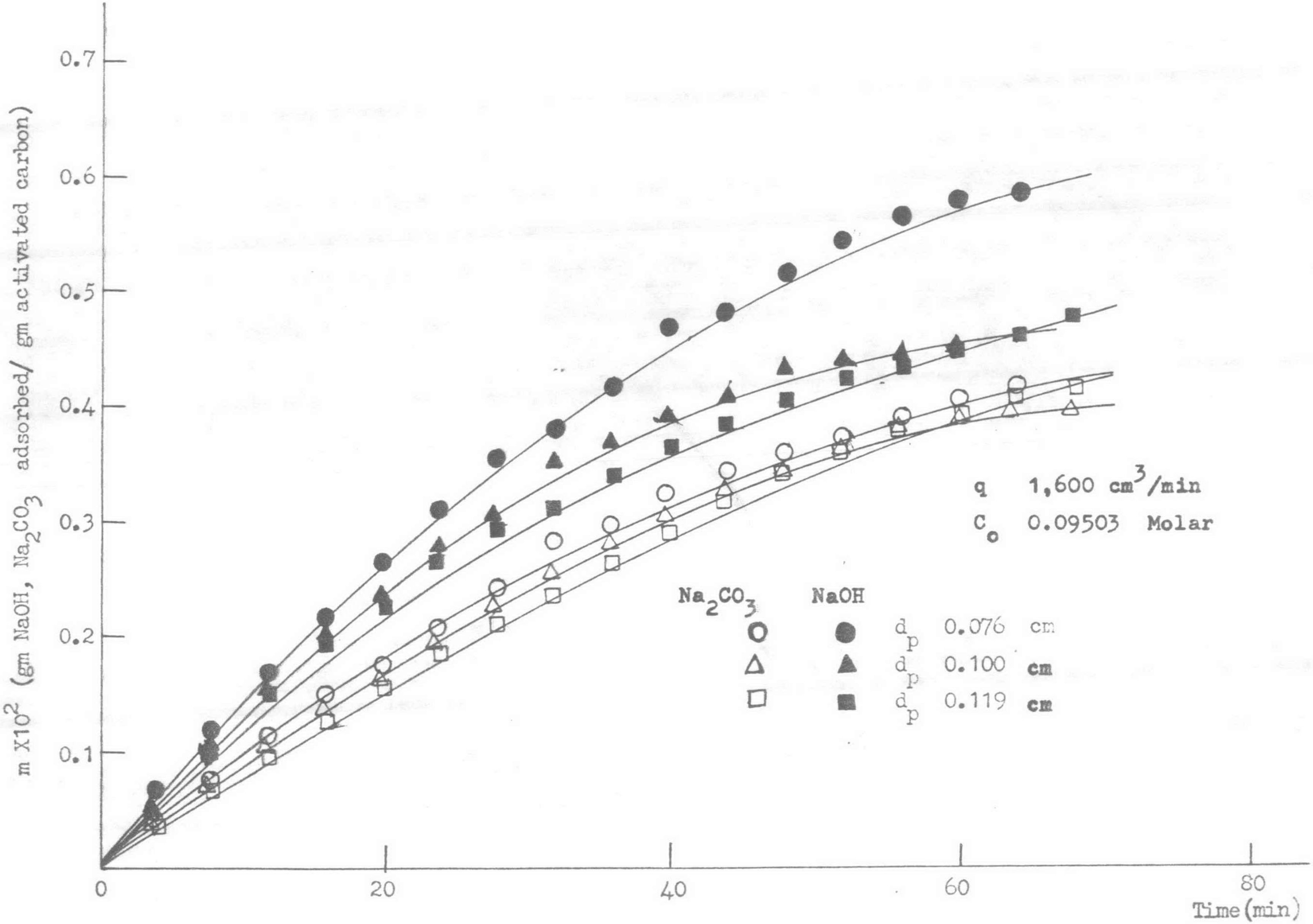

Fig.4.8 Variation of Adsorptive Capacity (m) with Time (t) for Adsorption of the Mixture of NaOH and Na_2CO_3 on Activated Carbon and Various Sizes of Activated Carbon

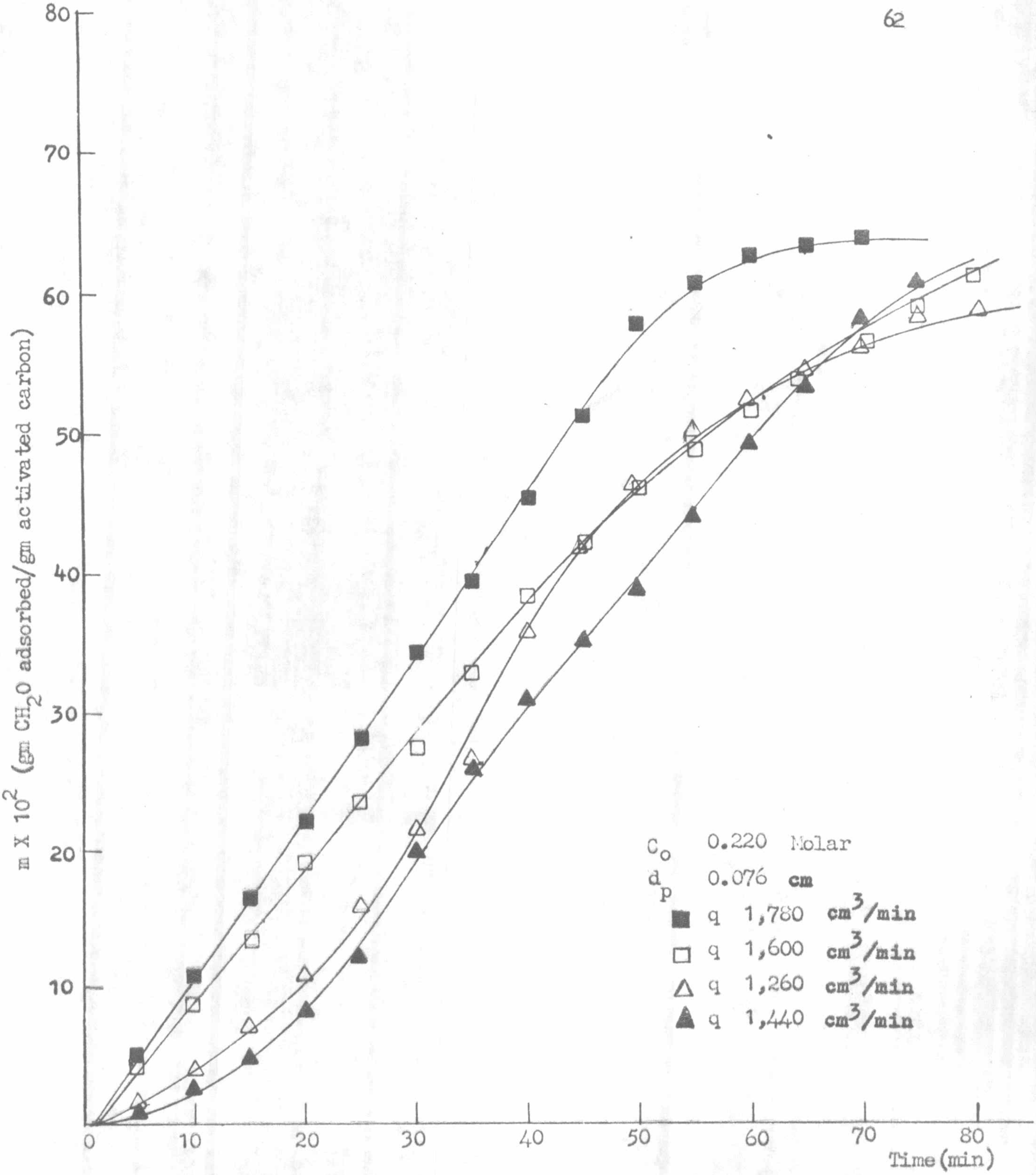

Fig.4.9 Variation of Adsorptive Capacity (m) with Time (t) for Adsorption of Formaldehyde on Activated Carbon at Various Feed Rates.

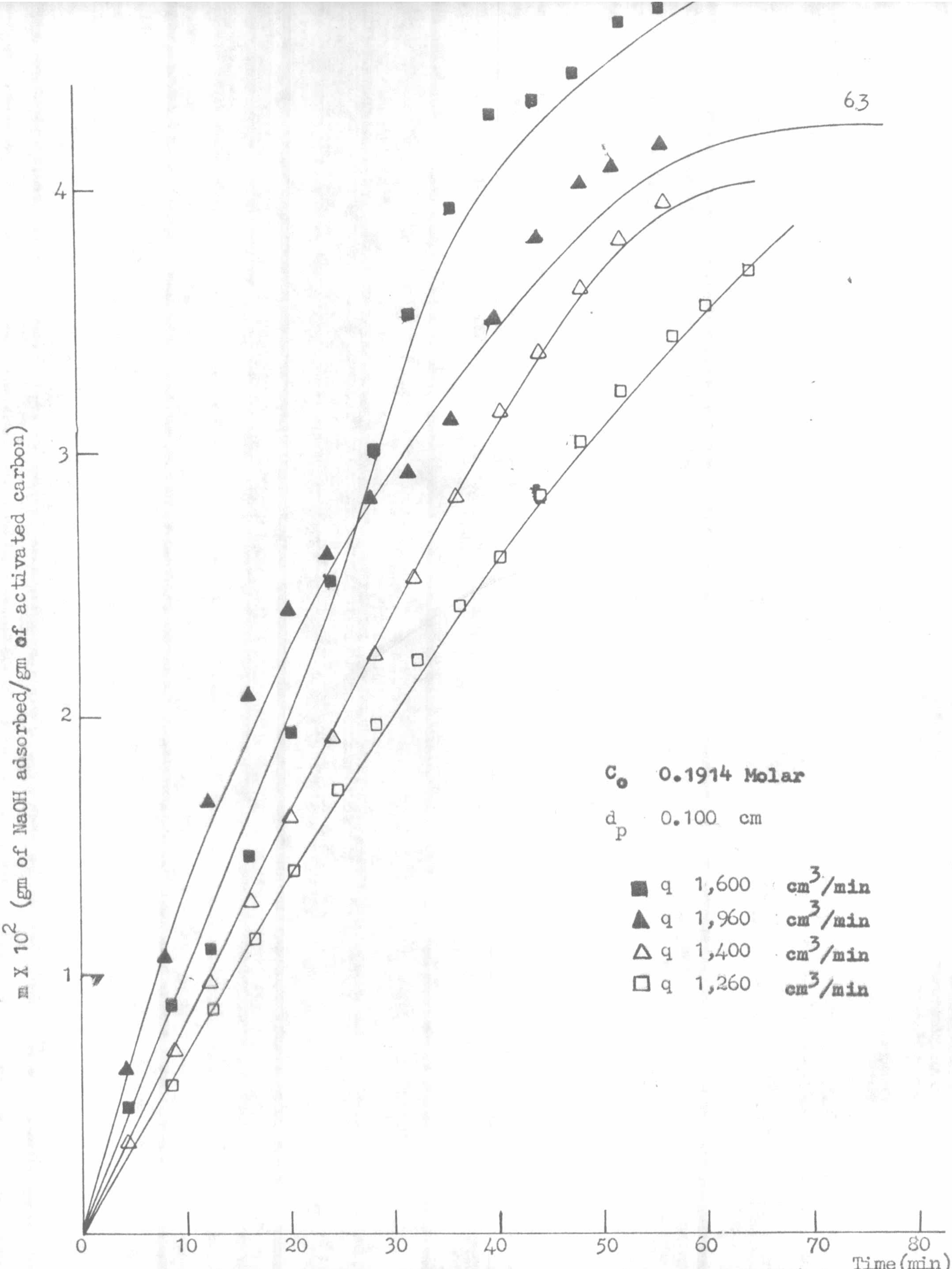

Fig.4.10 Variation of Adsorptive Capacity (m) with Time (t) for Adsorption of Sodium Hydroxide at Various Feed Rates

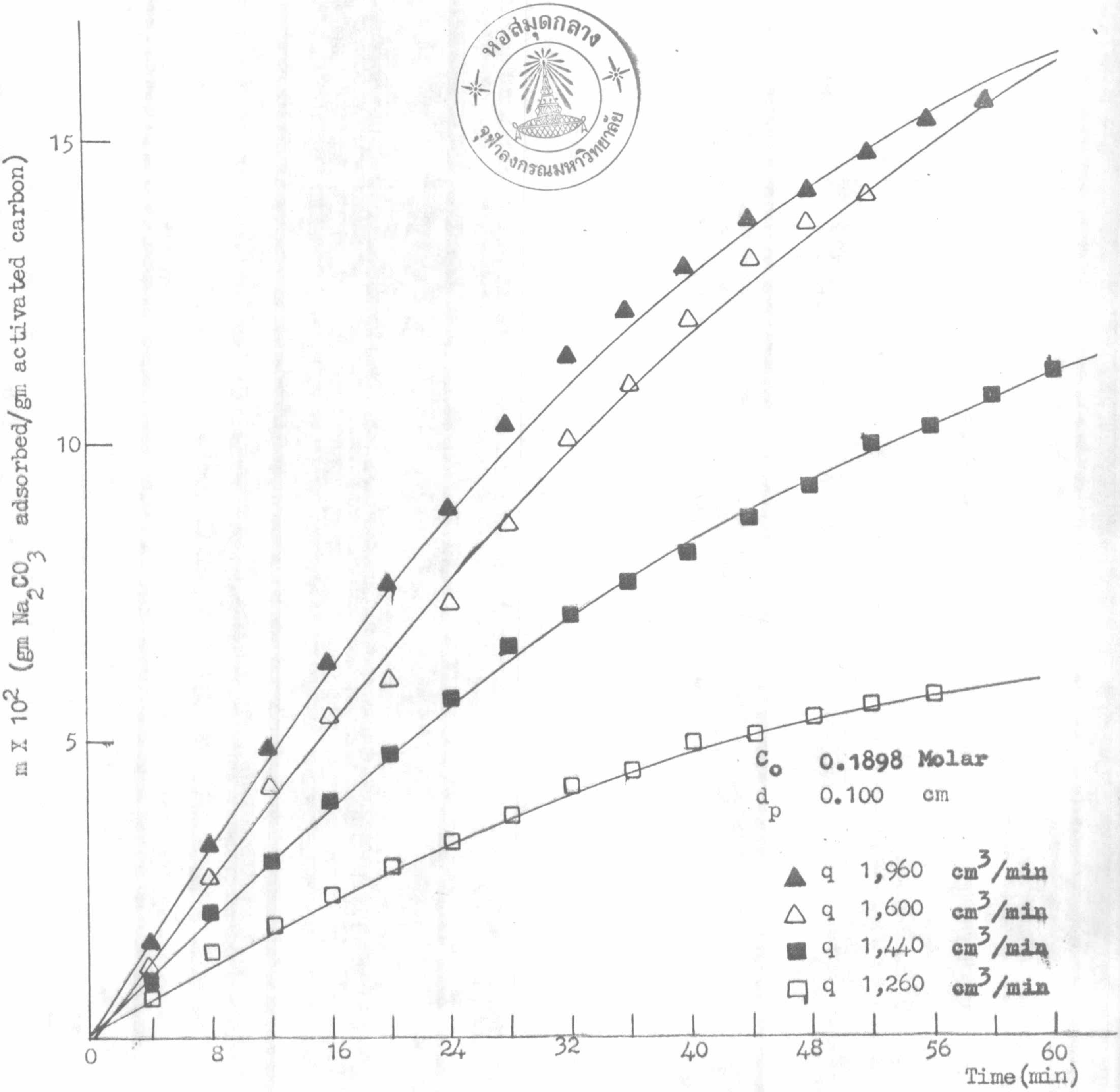

Fig.4.11 Variation of Adsorptive Capacity (m) with Time (t) for Adsorption of Sodium Carbonate on Activated Carbon at Various Feed Rates

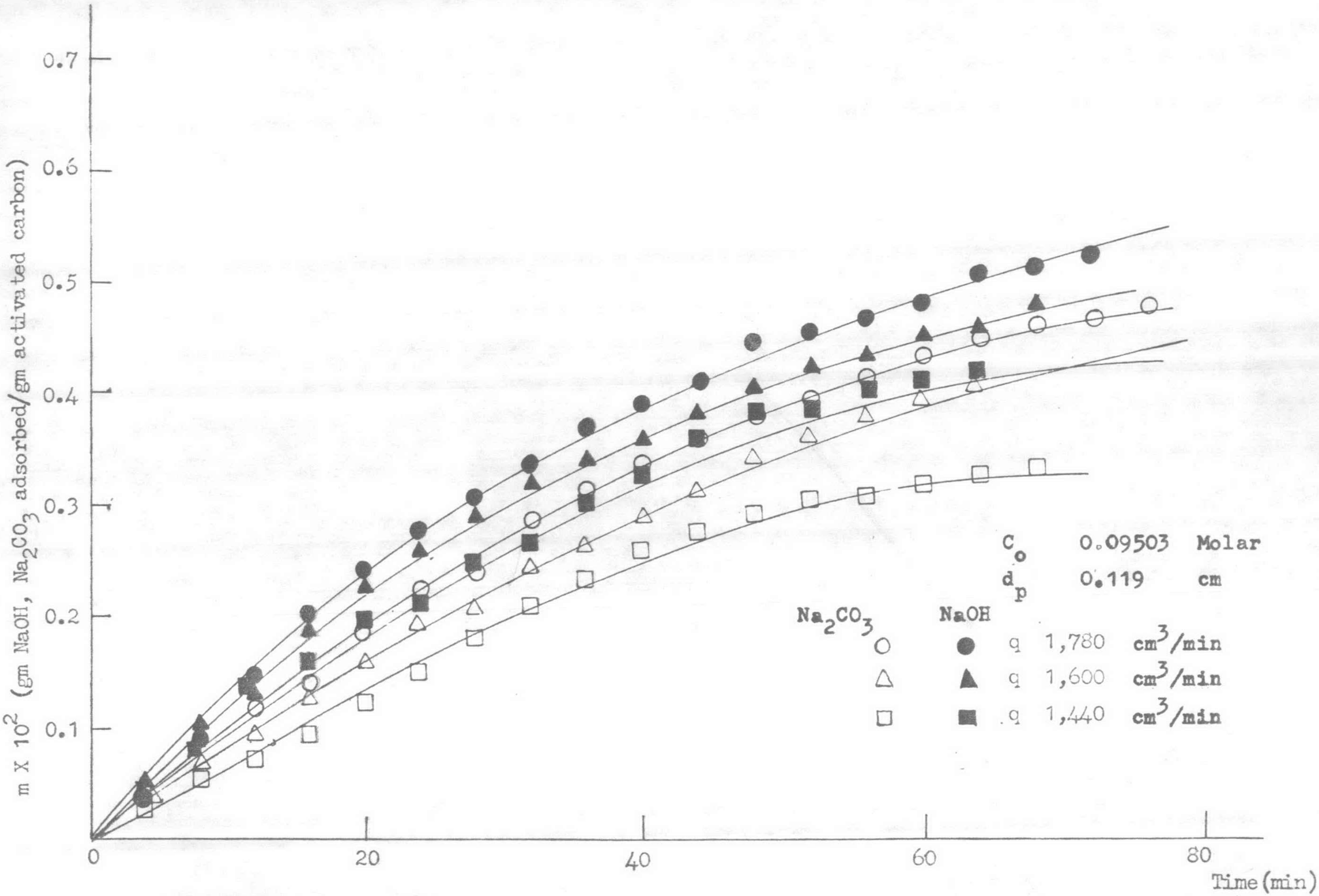

Fig.4.12 Variation of Adsorptive Capacity (m) with Time (t) for Adsorption of the Mixture of NaOH and Na_2CO_3 on Activated Carbon at Various Feed Rates

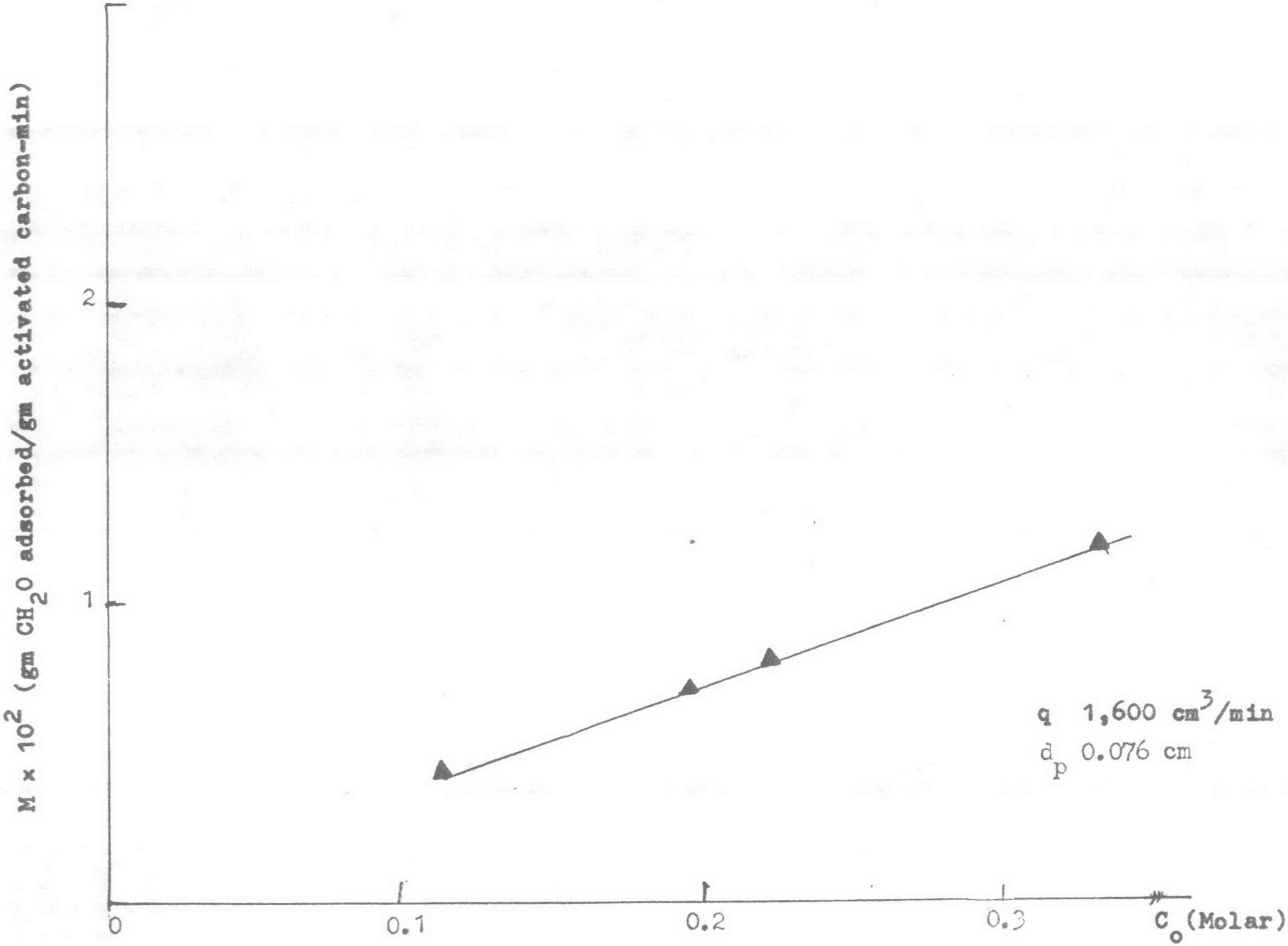

Fig.4.13 Effect of Concentration(C_o) on Mass Transfer Rate (M) for the Adsorption of Formaldehyde on Activated Carbon

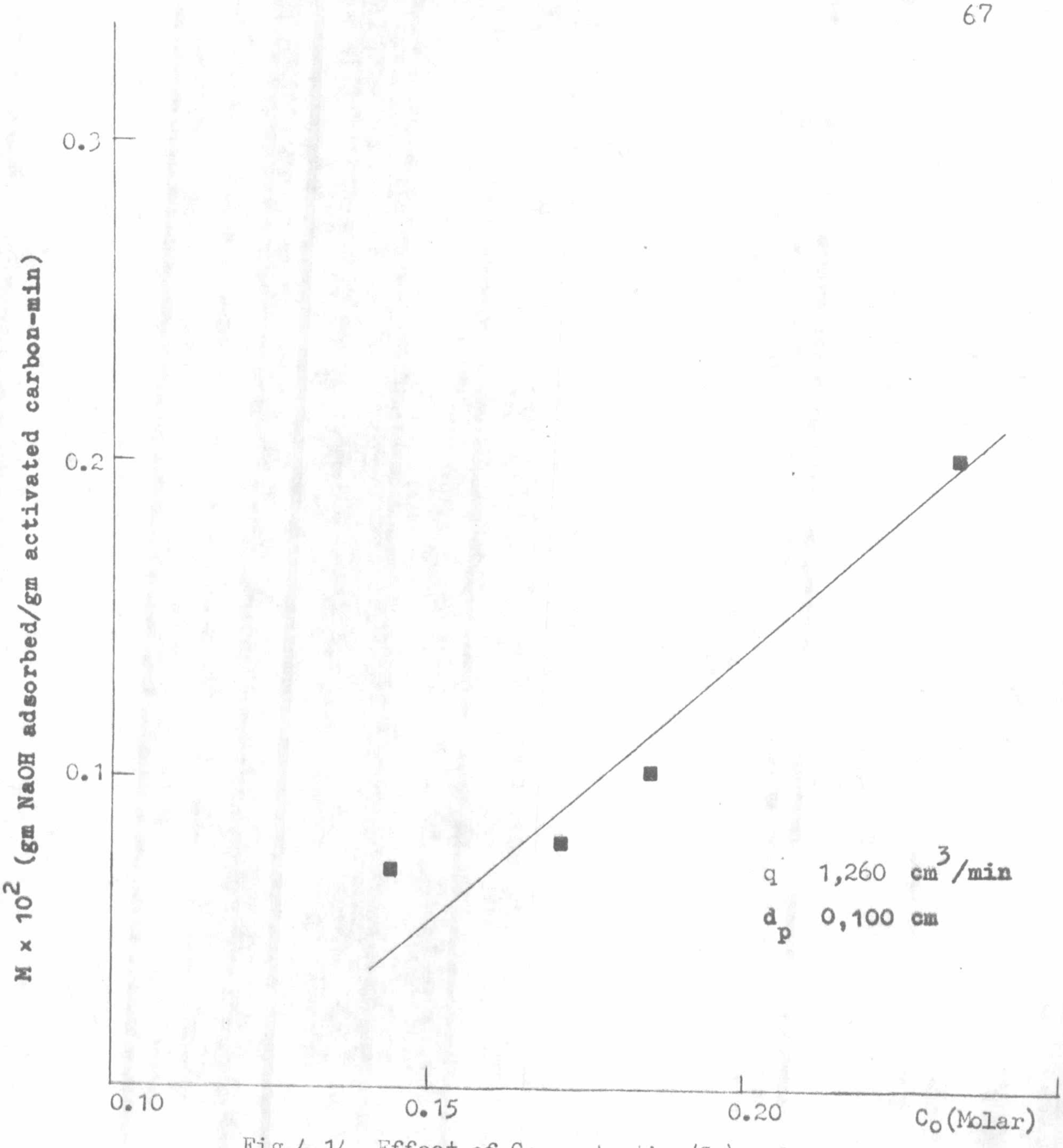

Fig.4.14 Effect of Concentration (C_o) on Mass Transfer Rate (M) for Adsorption of Sodium Hydroxide on Activated Carbon

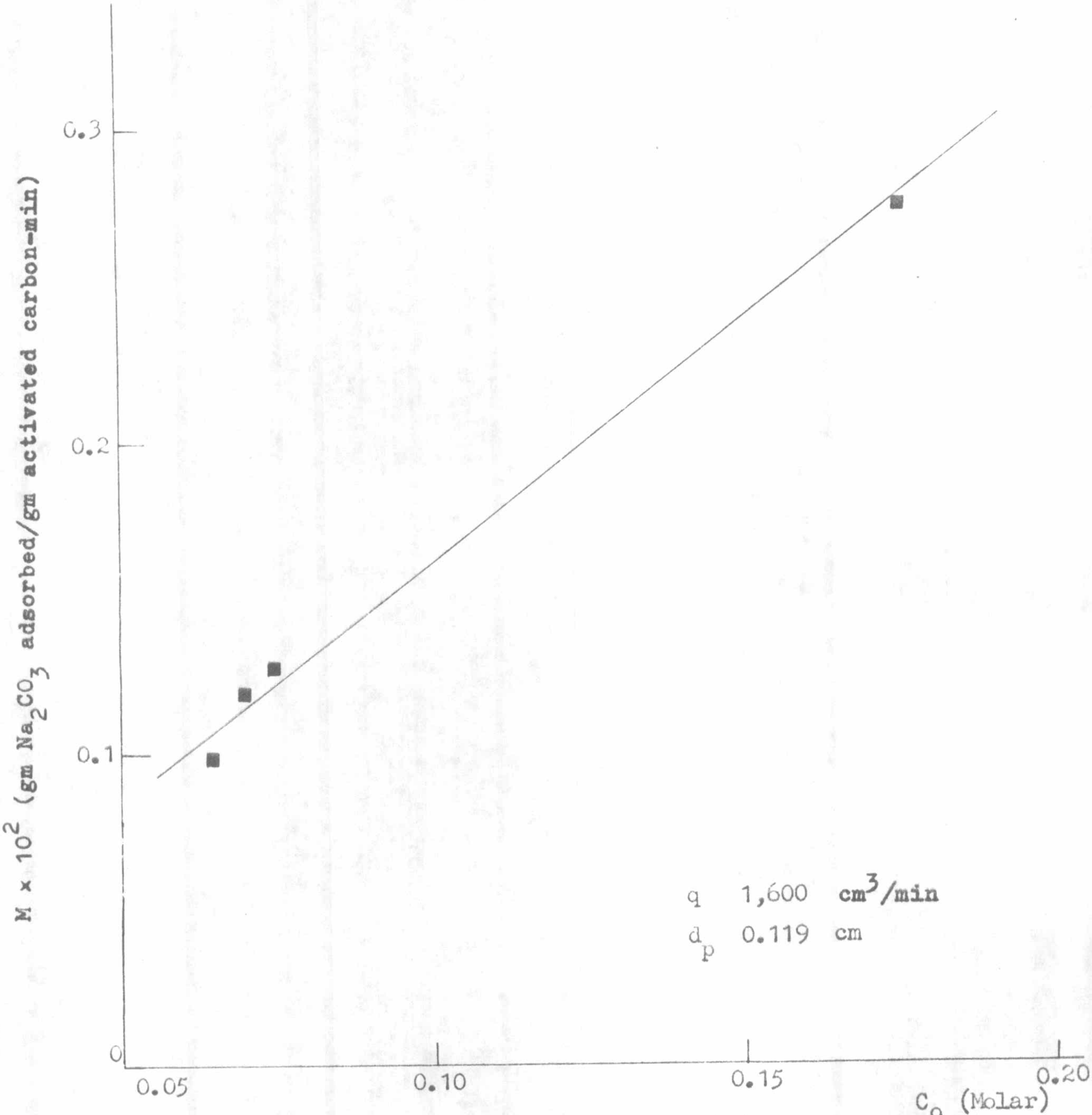

Fig.4.15 Effect of Concentration (C_o) on Mass Transfer Rate (M) for Adsorption of Sodium Carbonate on Activated Carbon

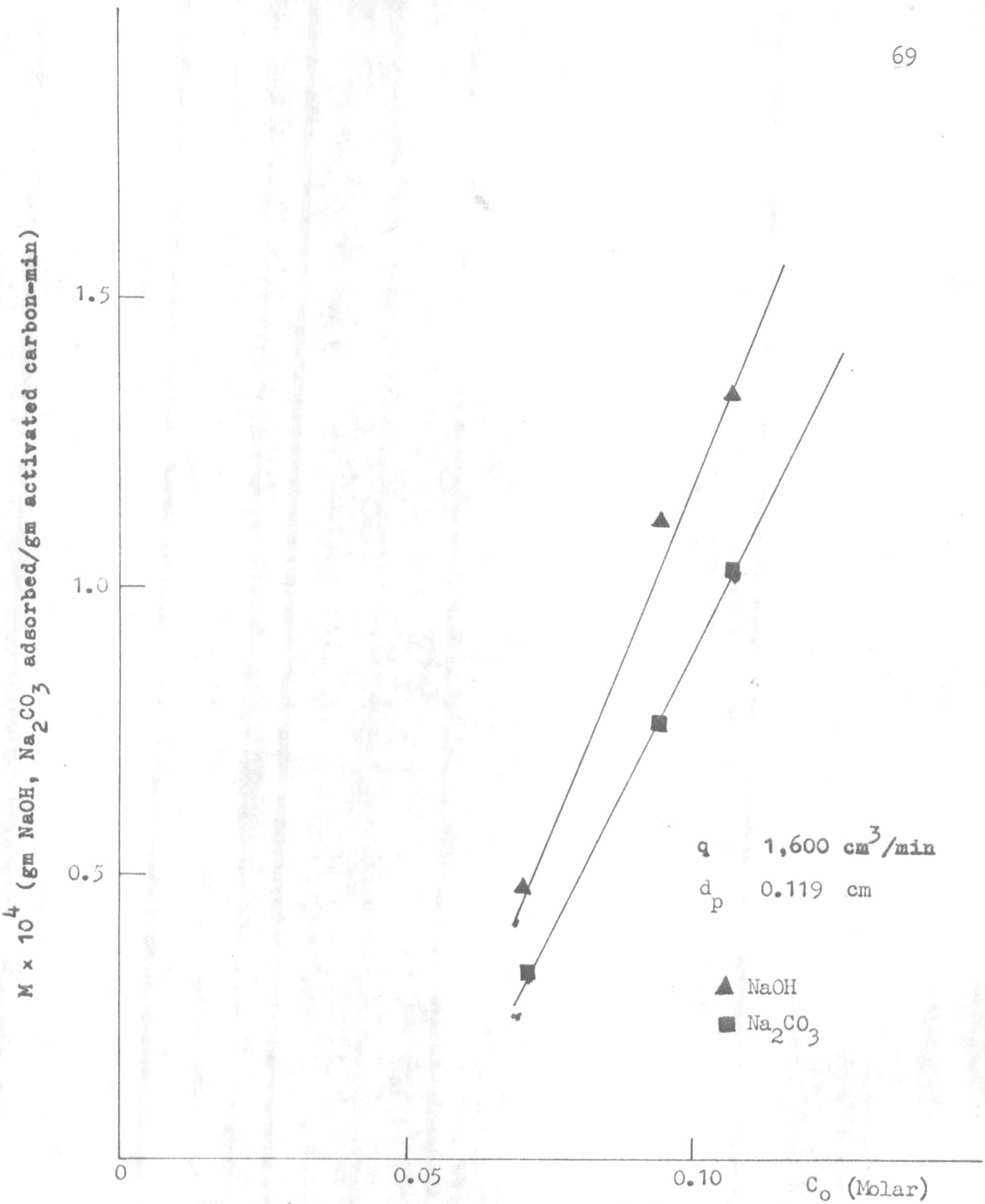

Fig.4.16 Effect of Concentration (C_o) on Mass Transfer Rare (M) for Adsorption of the Mixture of NaOH and Na_2CO_3 on Activated Carbon

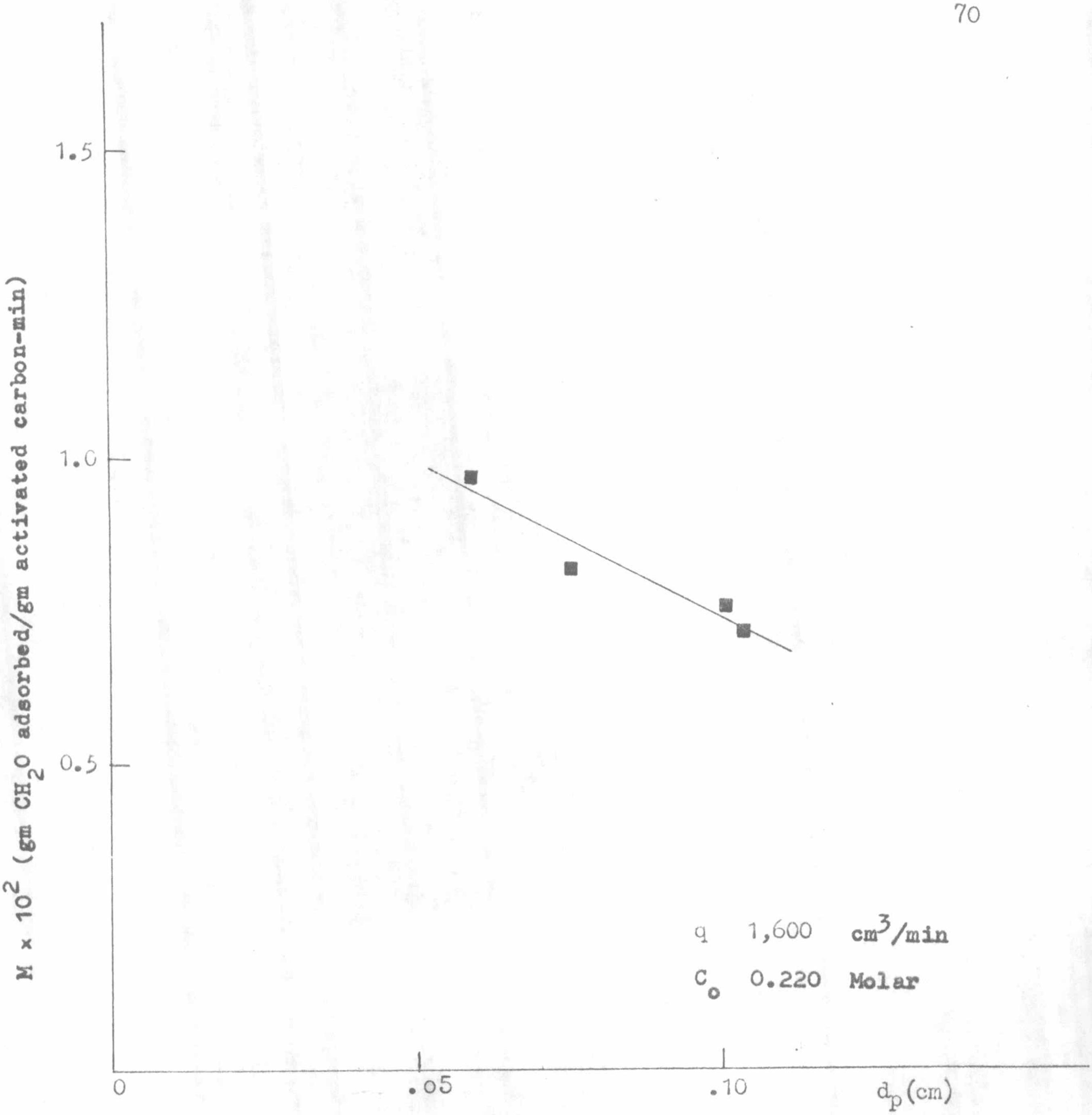

Fig.4.17 Effect of Sizes of Activated Carbon (d_p) on Mass Transfer Rate (M) for Adsorption of Formaldehyde on Activated Carbon

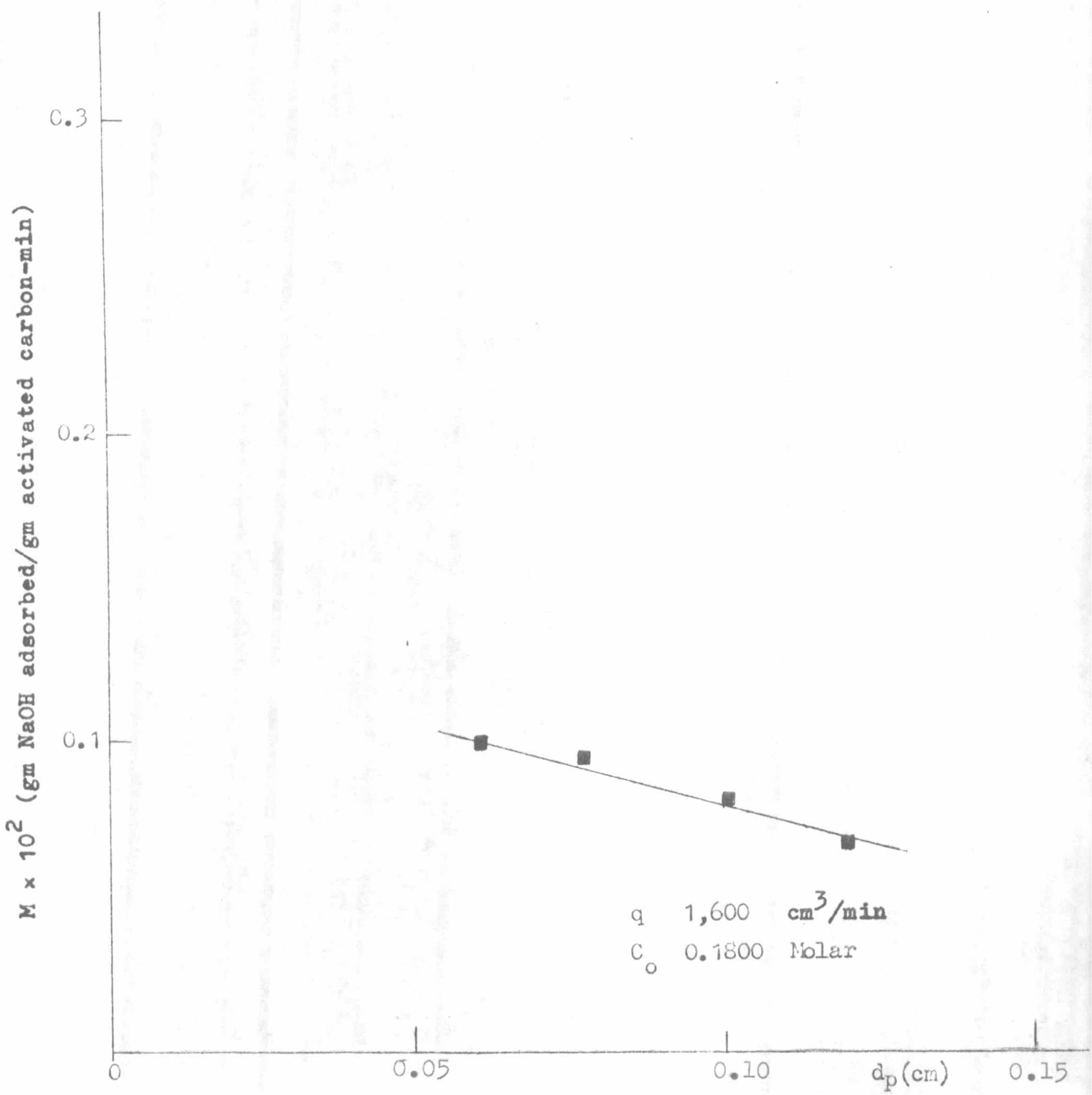

Fig.4.18 Effect of Sizes of Activated Carbon (d_p) on Mass Transfer Rate (M) for Adsorption of Sodium Hydroxide on Activated Carbon

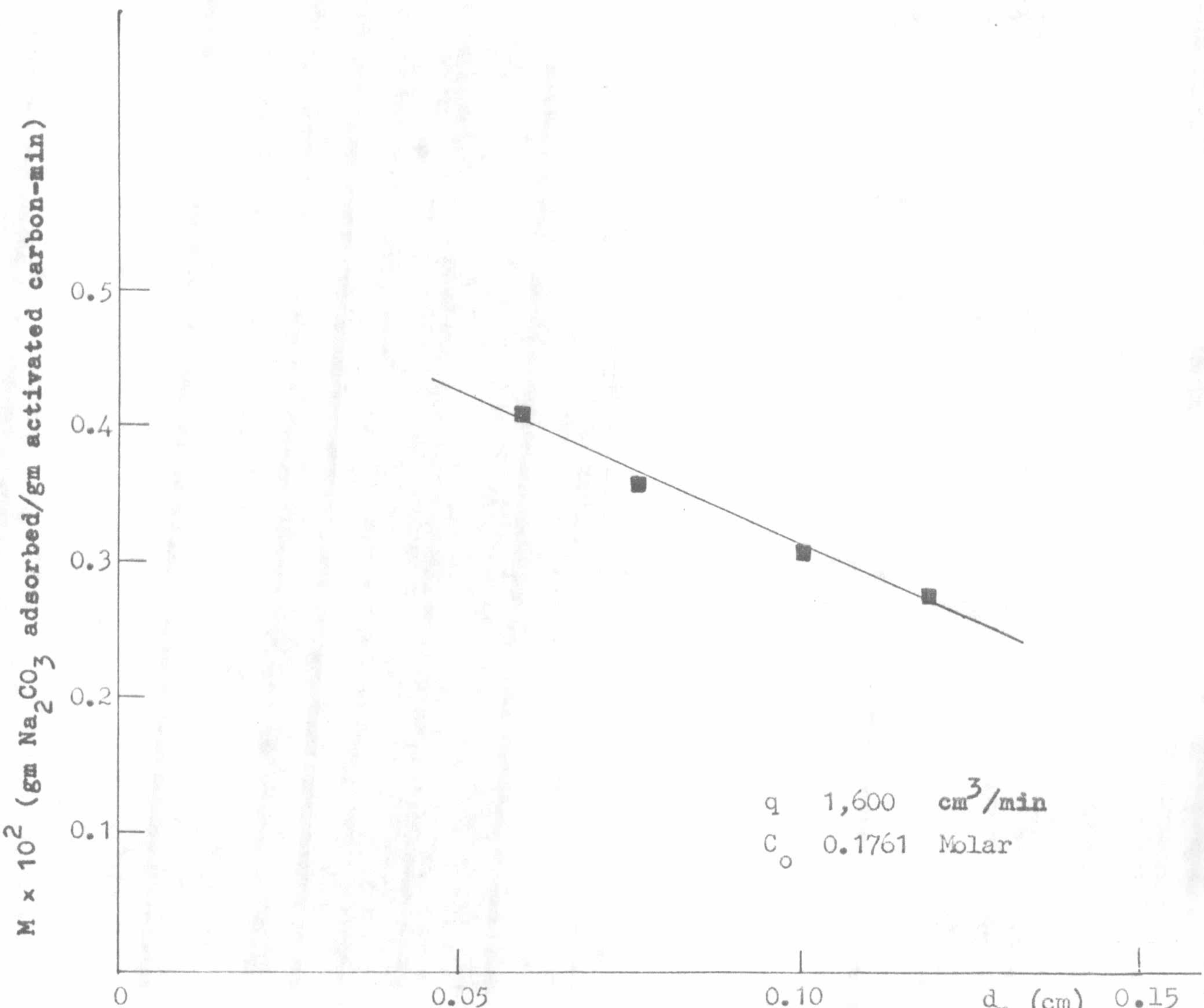

Fig.4.19 Effect of Sizes of Activated Carbon (d_p) on Mass Transfer Rate (M) for Adsorption of Sodium Carbonate on Activated Carbon

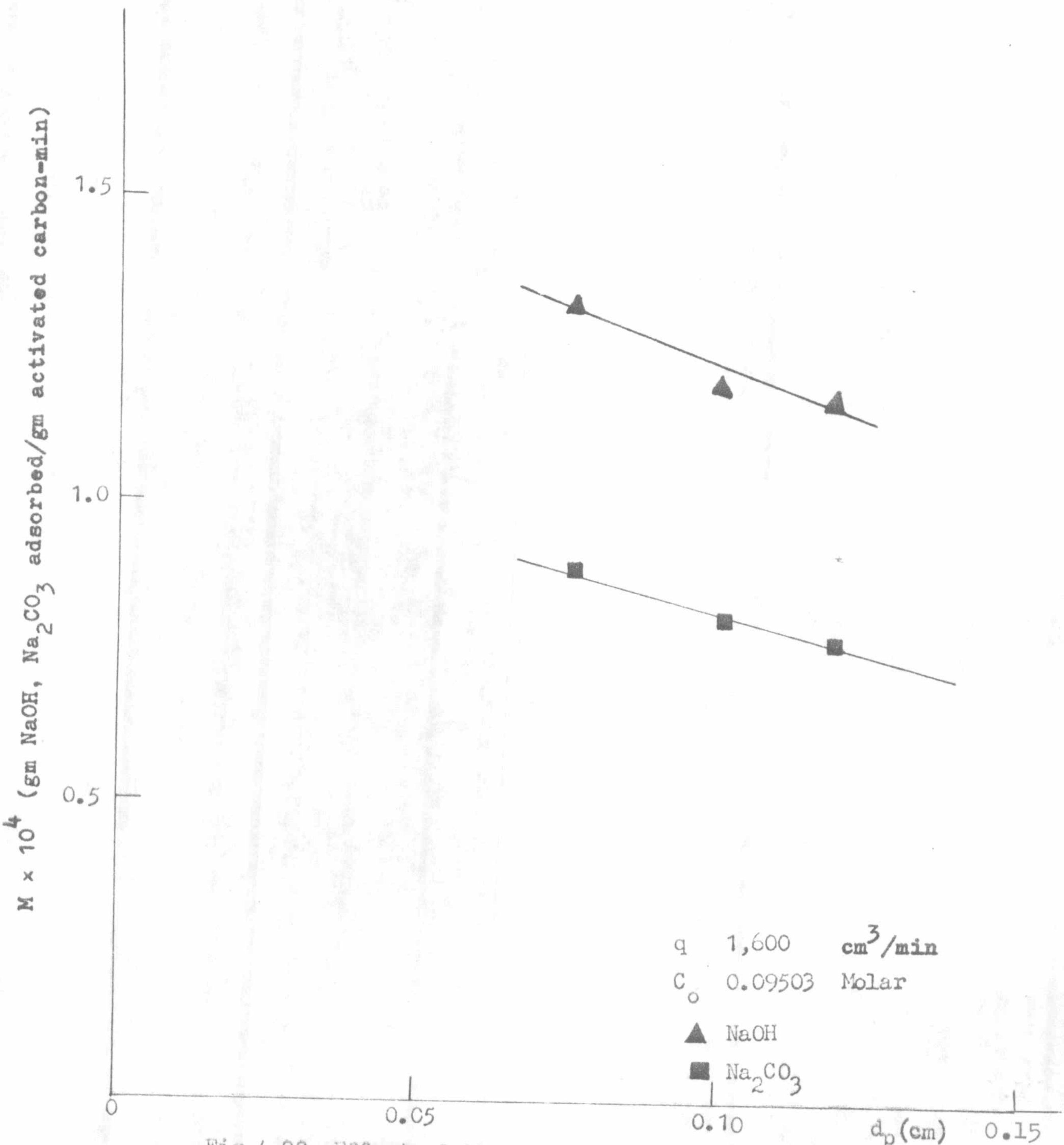

Fig.4.20 Effect of Sizes of Activated Carbon (d_p) on Mass Transfer Rate (M) for Adsorption of the Mixture of NaOH and Na_2CO_3 on Activated Carbon

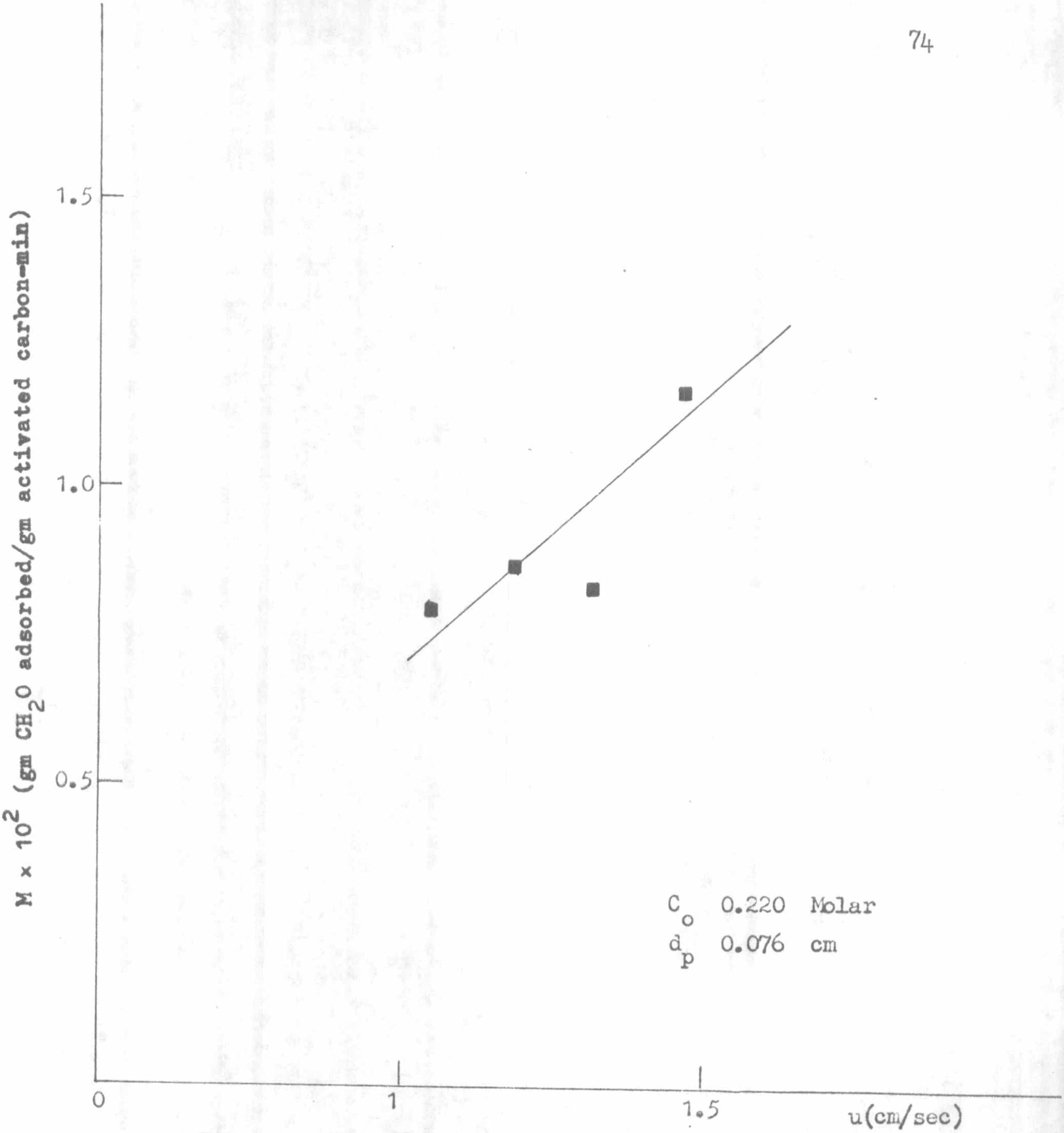

Fig.4.21 Effect of Velocity(u) on Mass Transfer Rate(M) for Adsorption of Formaldehyde on Activated Carbon

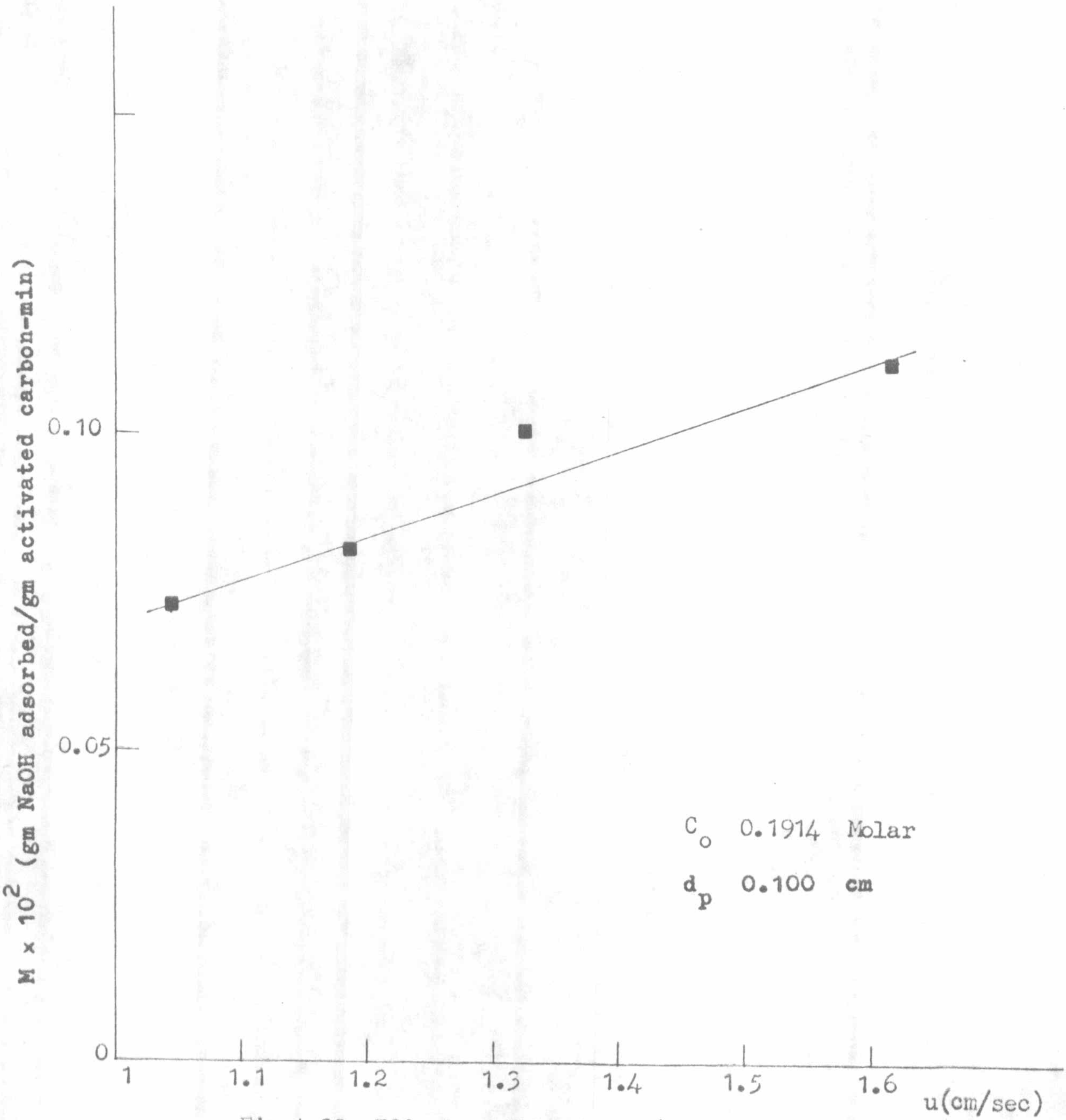

Fig.4.22 Effect of Velocity (u) on Mass Transfer Rate (M) for Adsorption of Sodium Hydroxide on Activated Carbon

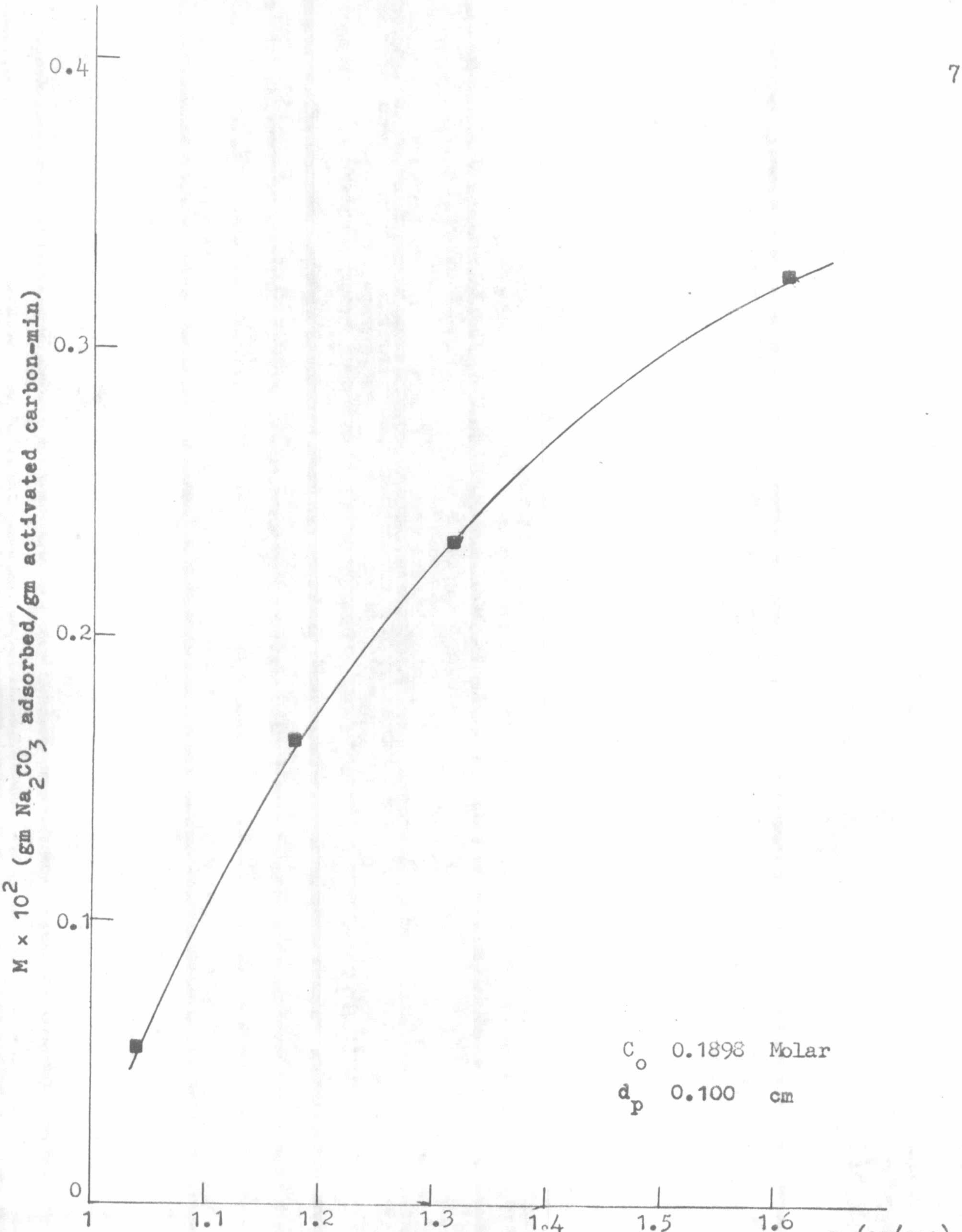

Fig.4.23 Effect of Velocity (u) on Mass Transfer Rate (M) for Adsorption of Sodium Carbonate on Activated Carbon

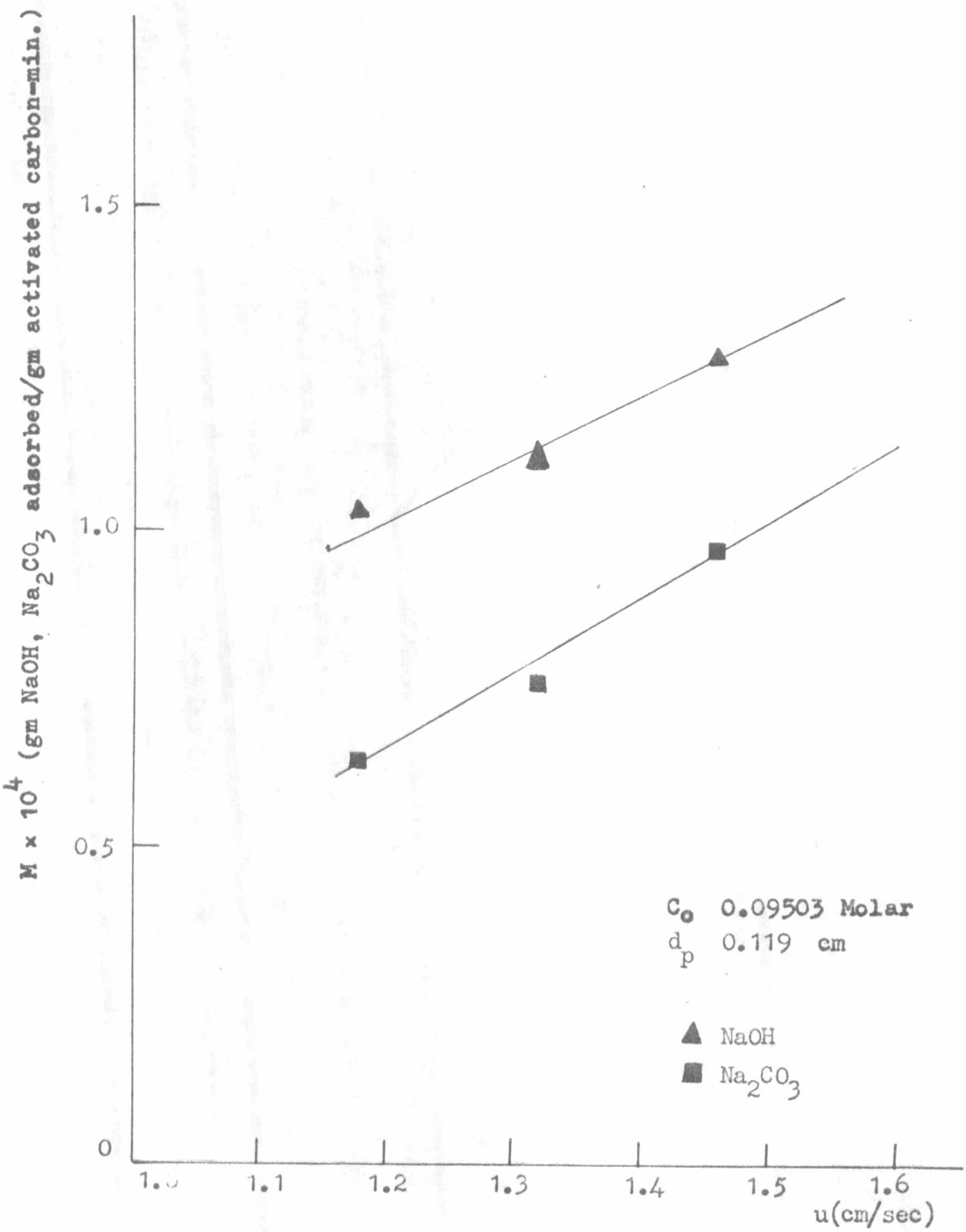

Fig.4.24 Effect of Velocity (u) on Mass Transfer Rate (M) for Adsorption of the Mixture of NaOH and Na_2CO_3 on Activated Carbon

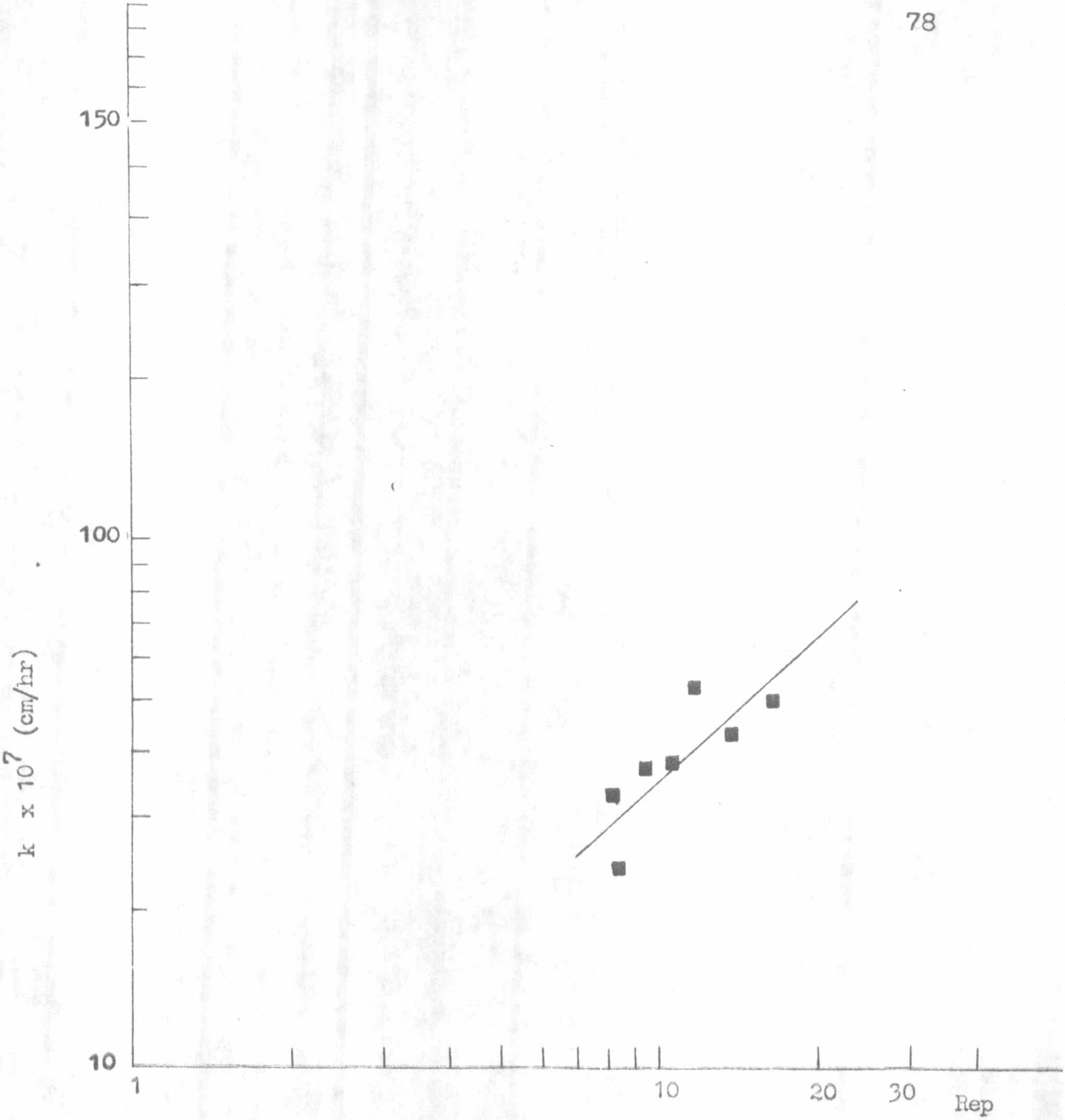

Fig.4.25 Effect of Rep on Mass Transfer Coefficient(k)for the Adsorption of Formaldehyde on Activated Carbon

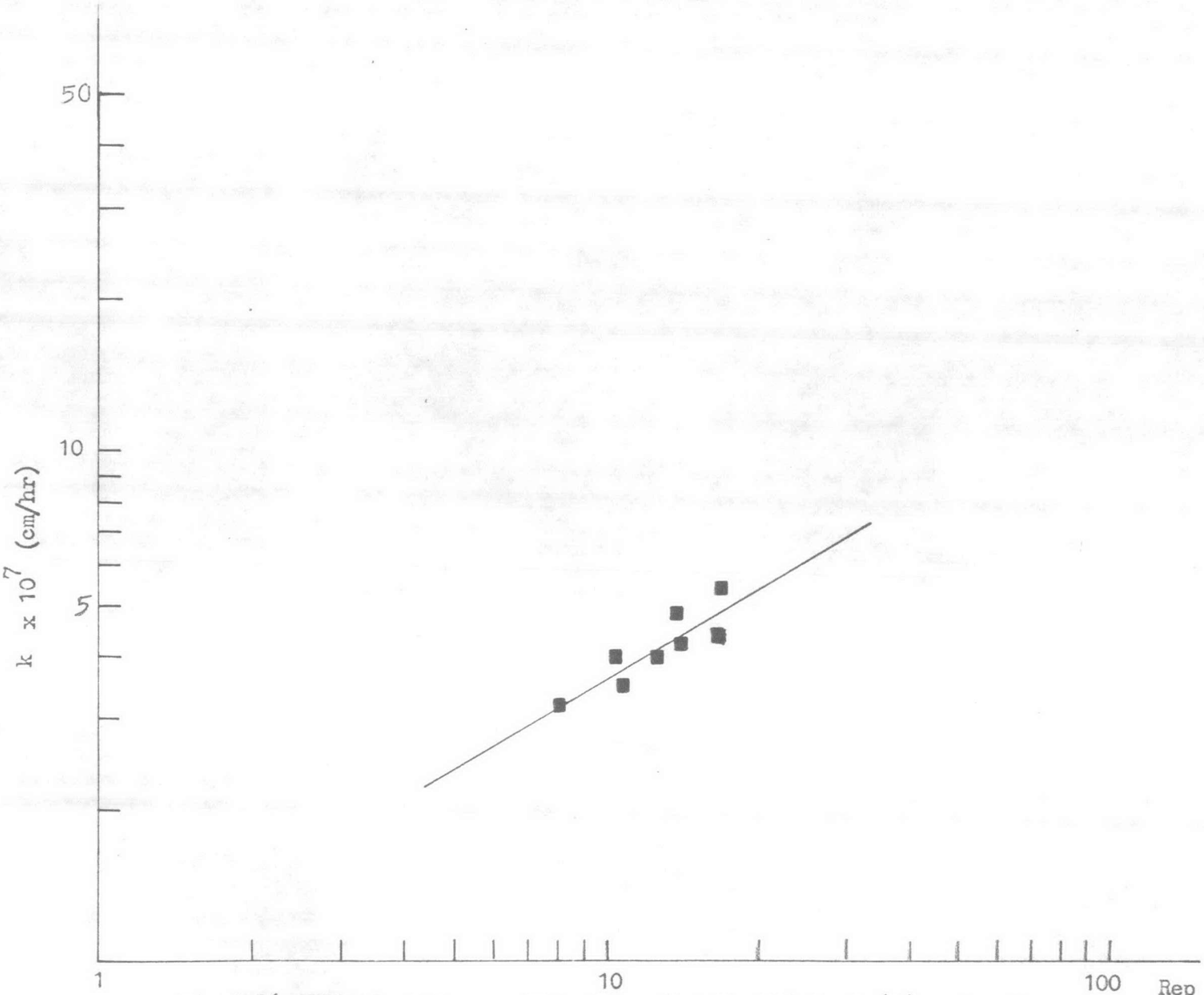

Fig.4.26 Effect of Rep on **Mass Transfer Coefficient (k)** for the Adsorption of Sodium Hydroxide on Activated Carbon

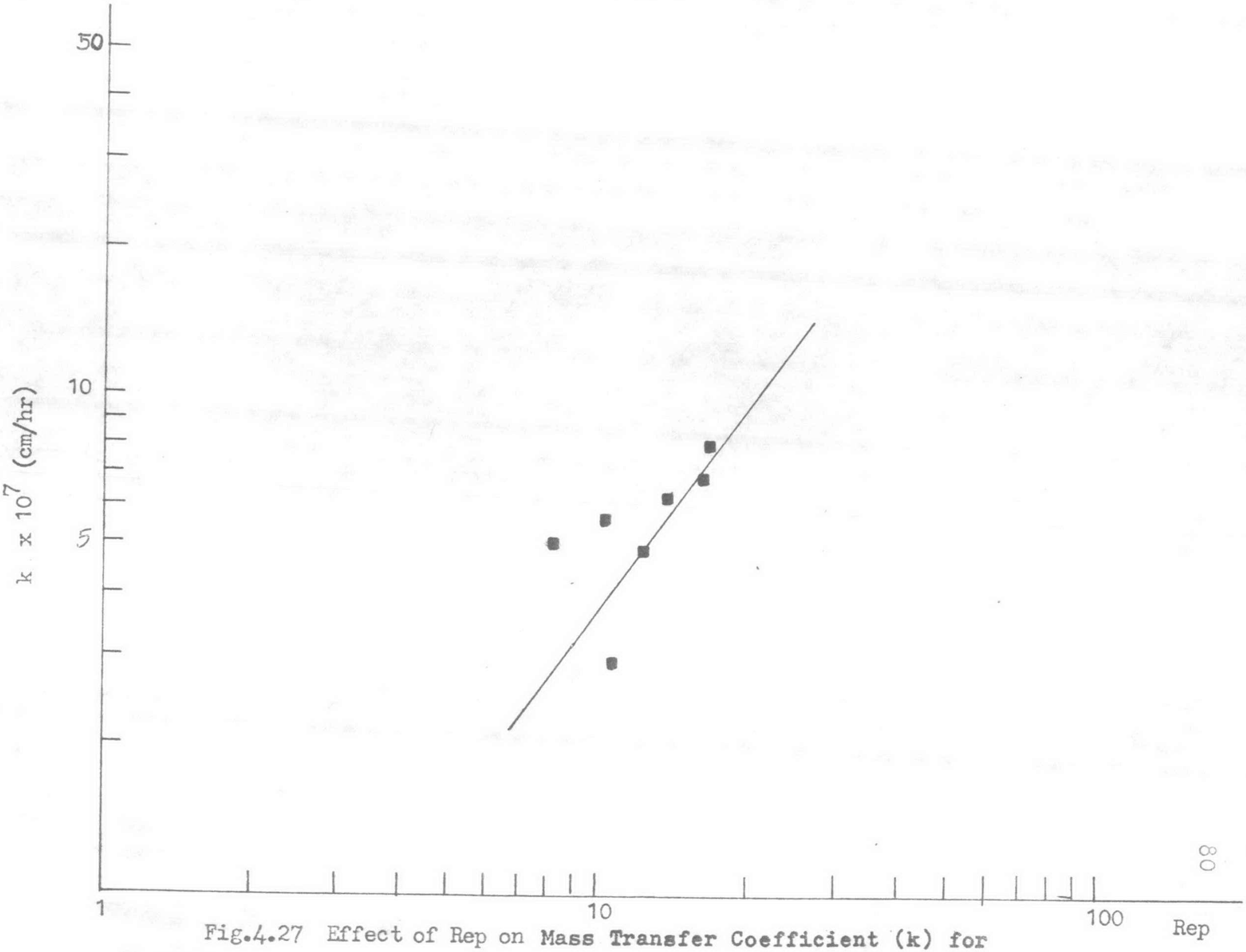

Fig.4.27 Effect of Rep on **Mass Transfer Coefficient (k) for** Adsorption of Sodium Carbonate on Activated Carbon

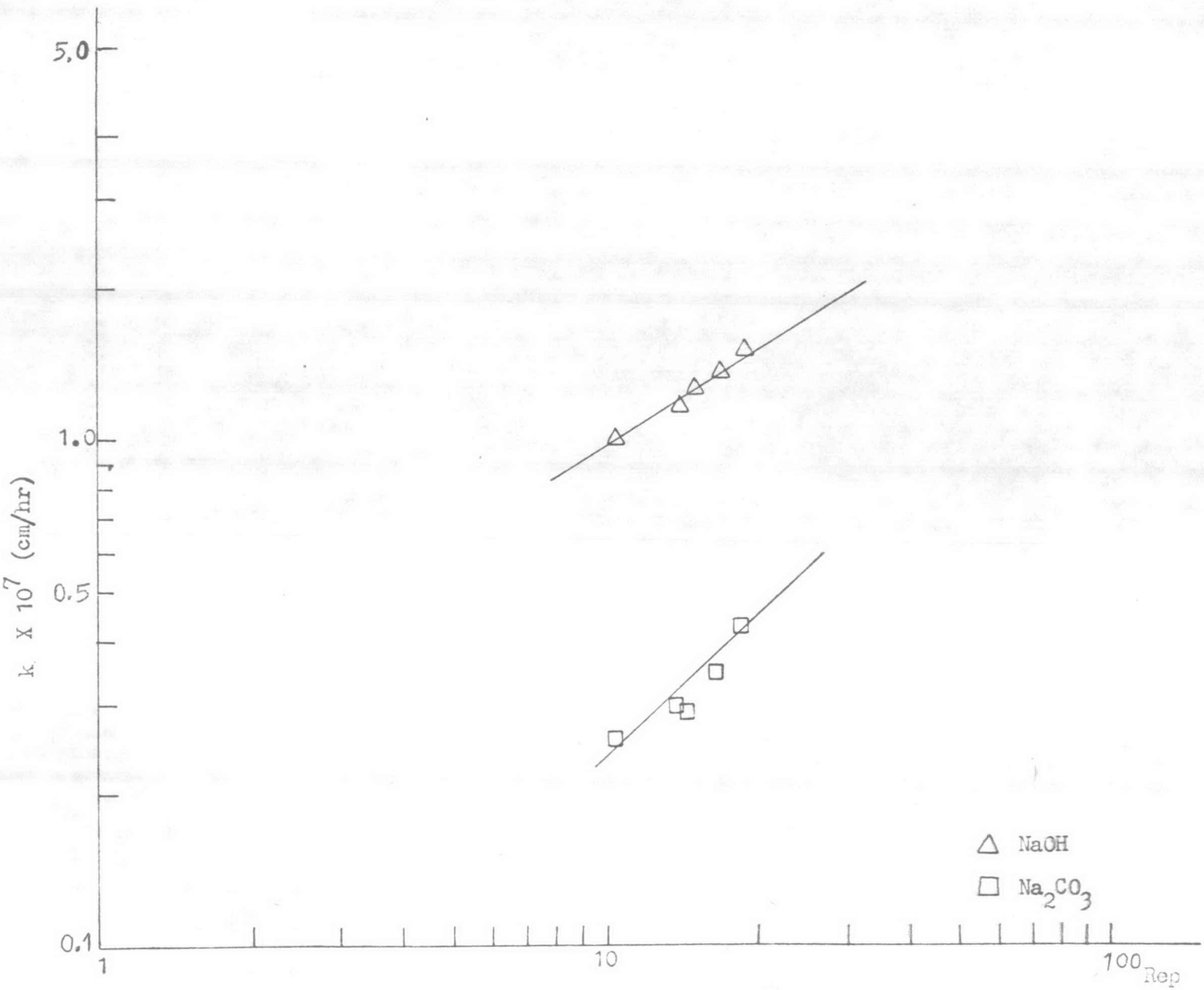

Fig.4.28 Effect of Rep on Mass Transfer Coefficient (k) for Adsorption of the Mixture of NaOH and Na_2CO_3 on Activated Carbon

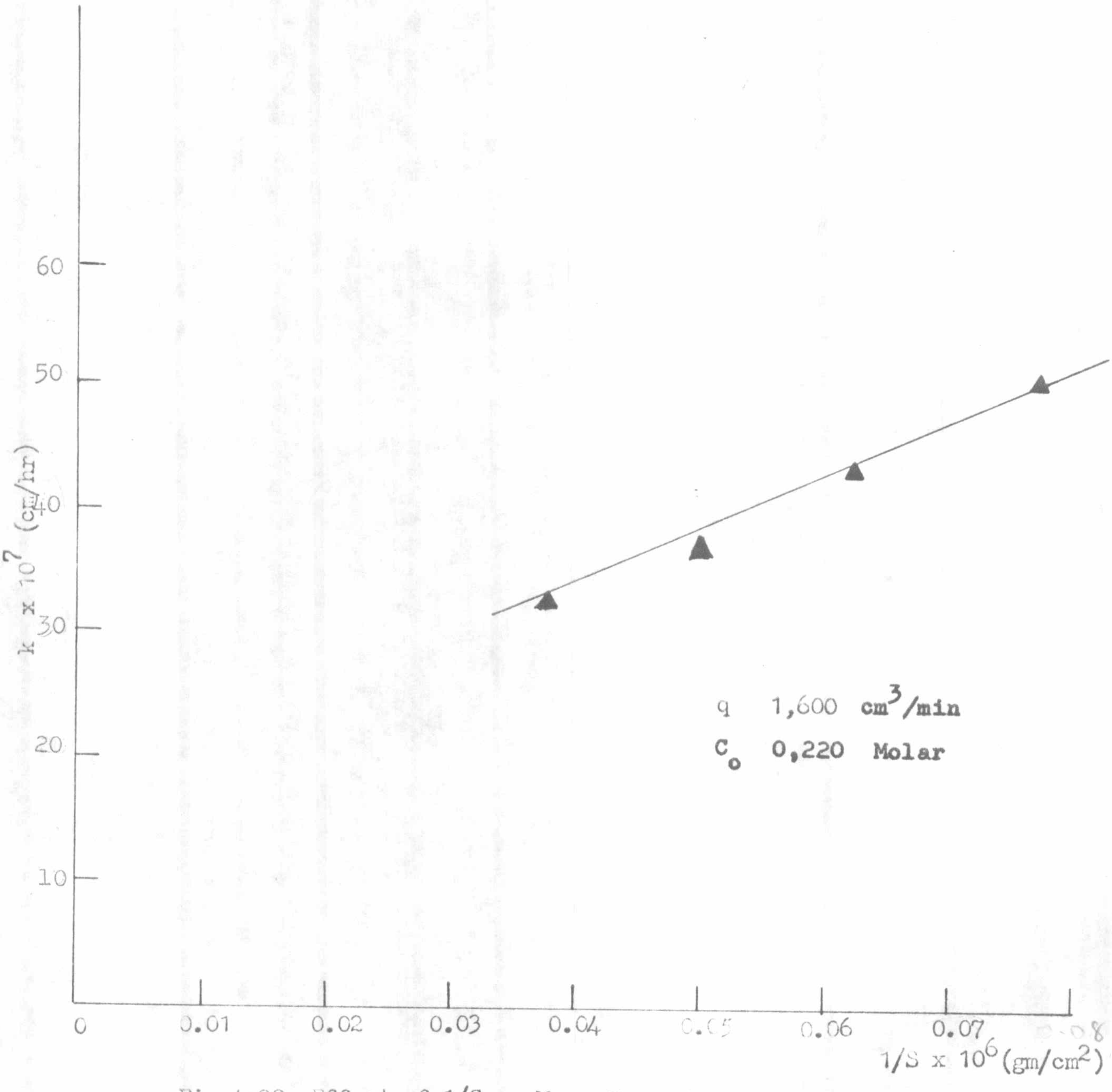

Fig.4.29 Effect of 1/S on **Mass Transfer Coefficient** (k) for the Adsorption of Formaldehyde on Activated Carbon

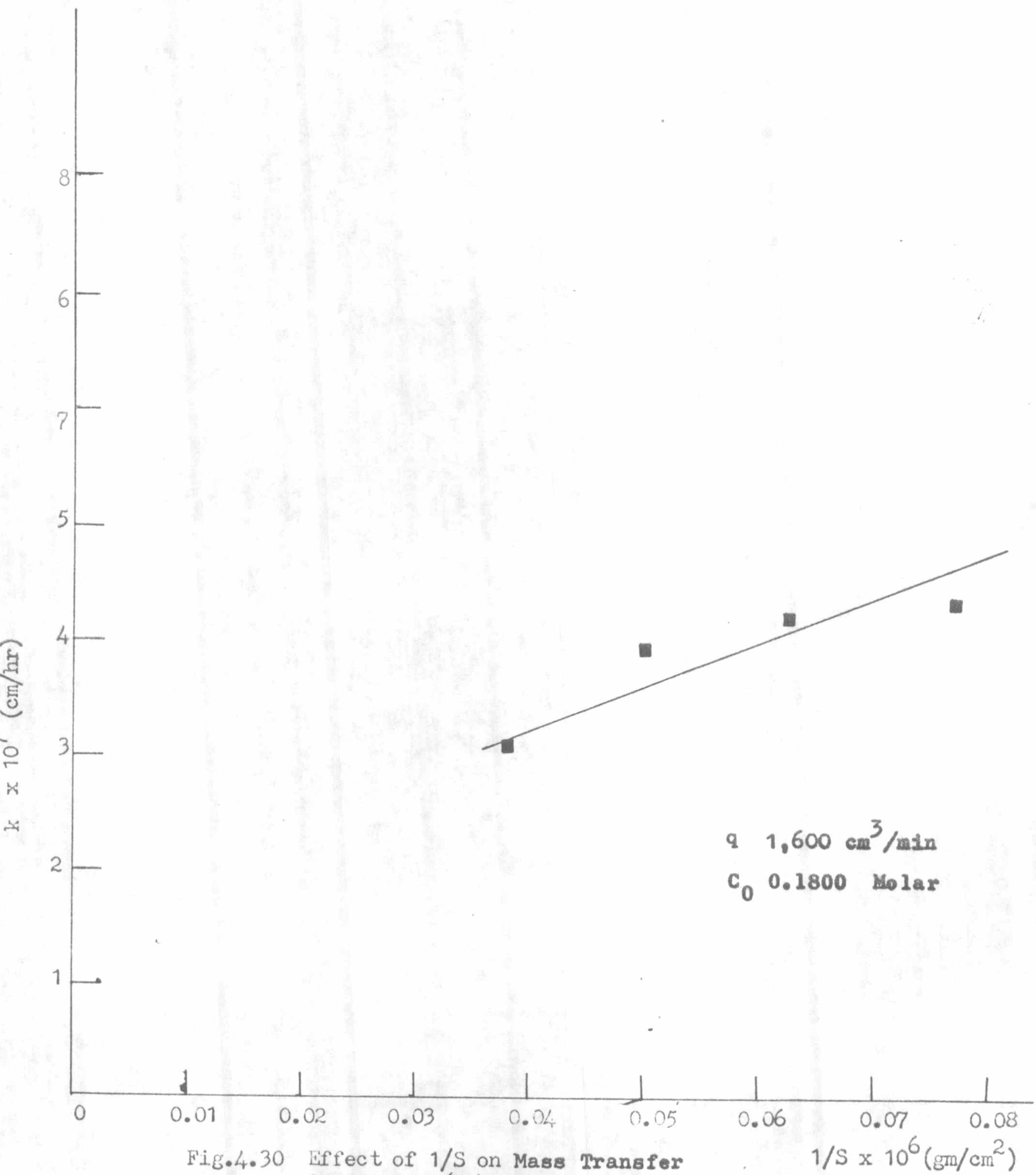

Fig.4.30 Effect of 1/S on **Mass Transfer** Coefficient(k) for the Adsorption of Sodium Hydroxide on Activated Carbon

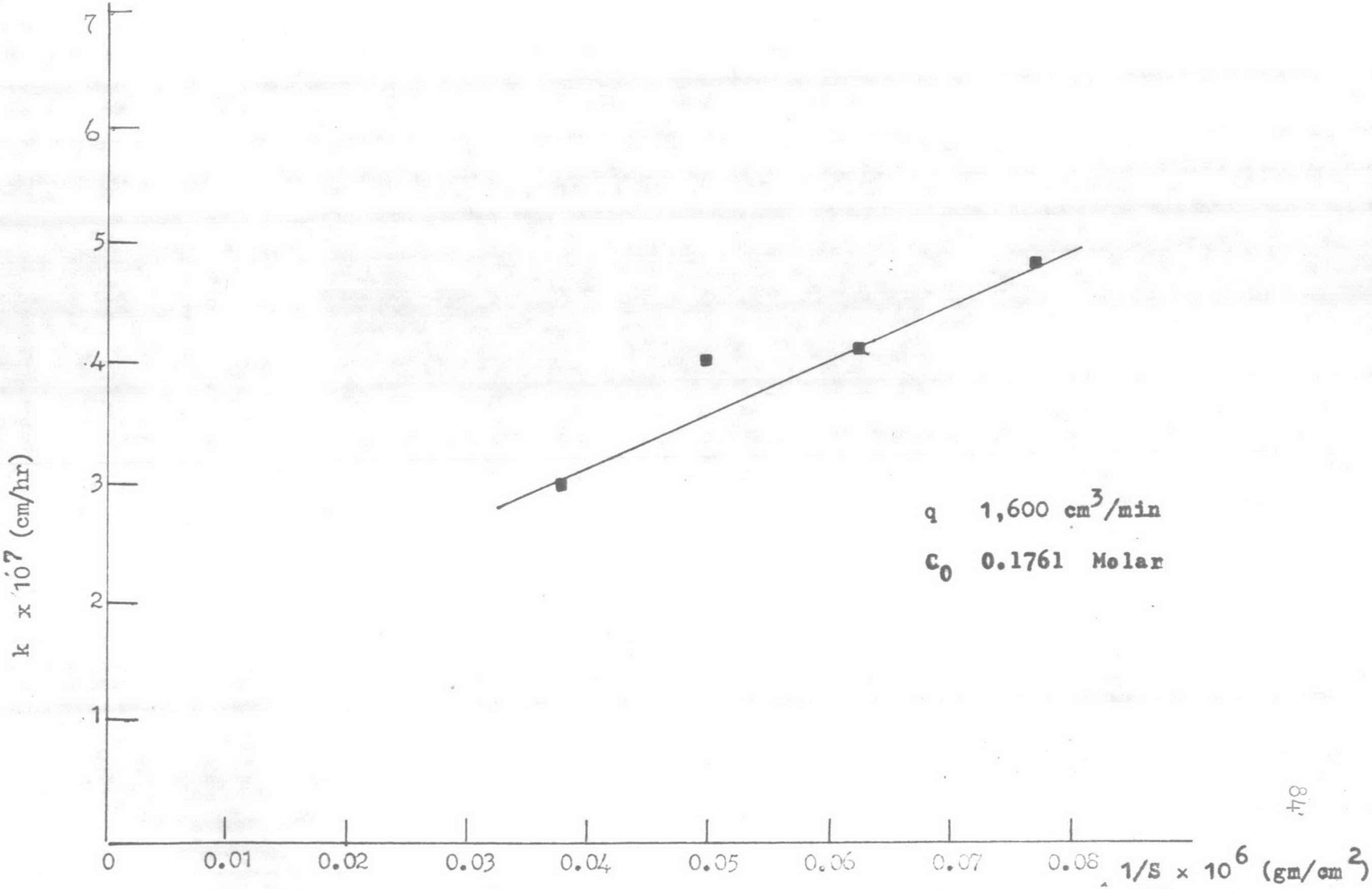

Fig.4.31 Effect of 1/S on Mass Transfer Coefficient (k) for Adsorption of Sodium Carbonate on Activated Carbon

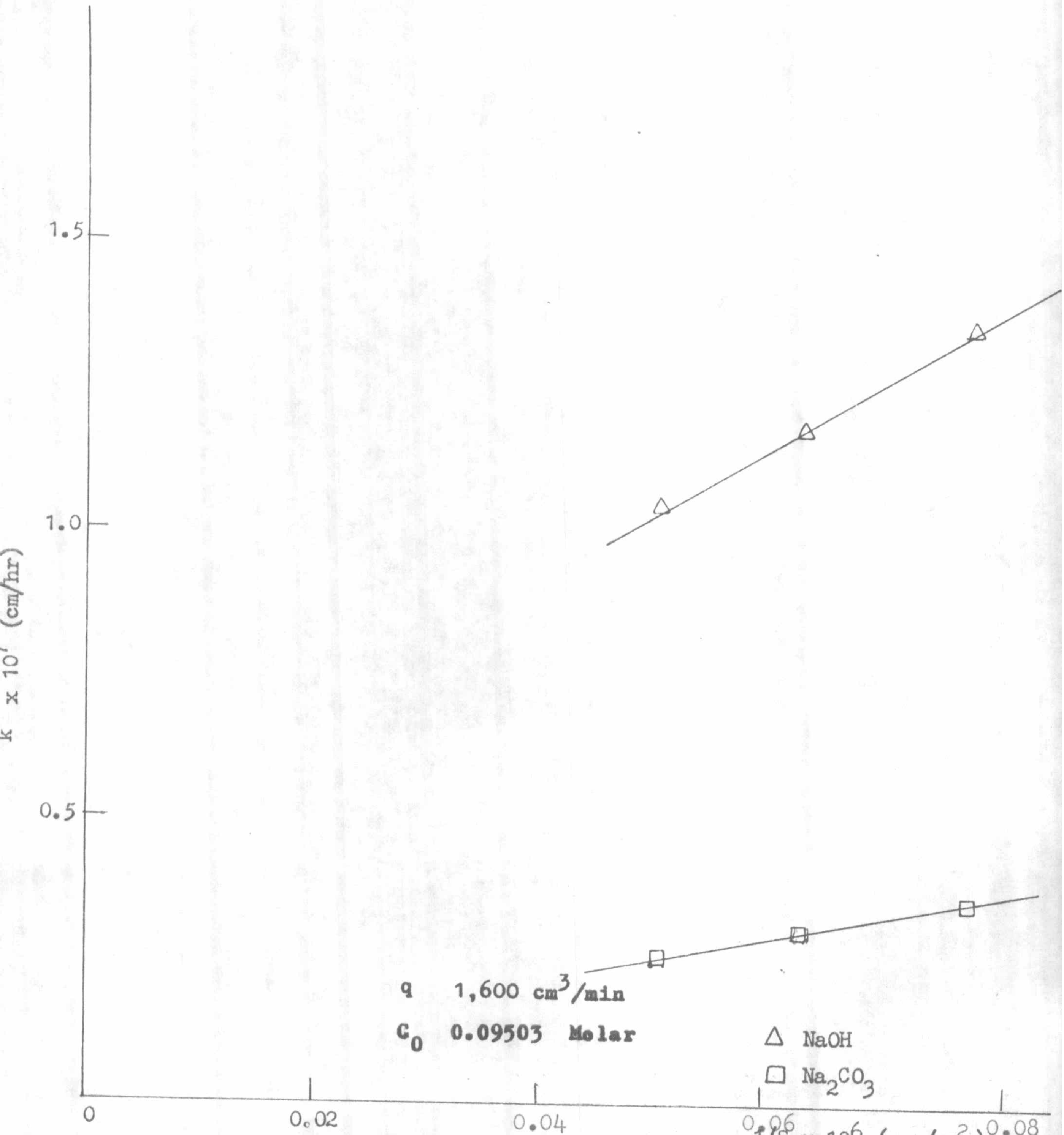

Fig.4.32 Effect of 1/S on **Mass Transfer** Coefficient (k) for Adsorption of the Mixture of NaOH and Na_2CO_3 on Activated Carbon