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Particle Analysis

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BET Theory and how its used to calculate surface area

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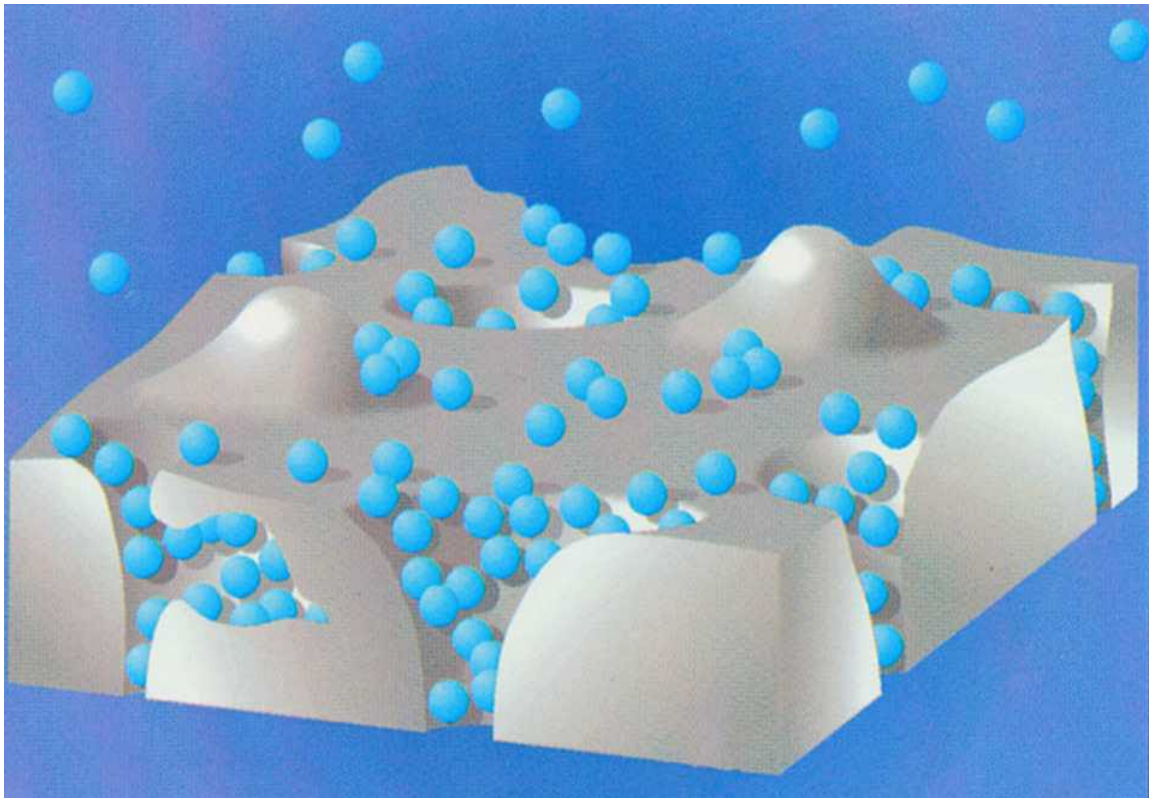
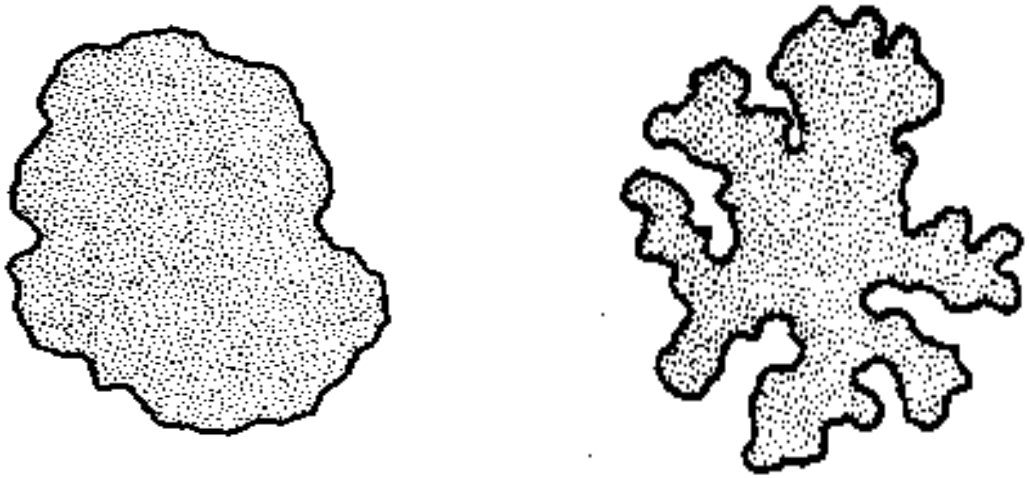
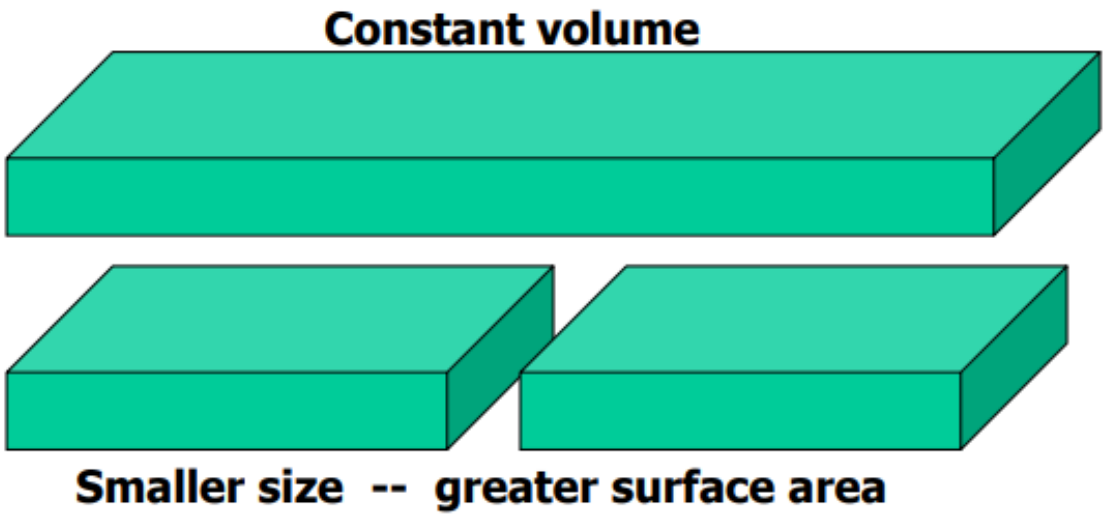
BET Theory seeks to explain the physical adsorption of gas molecules onto solid surfaces

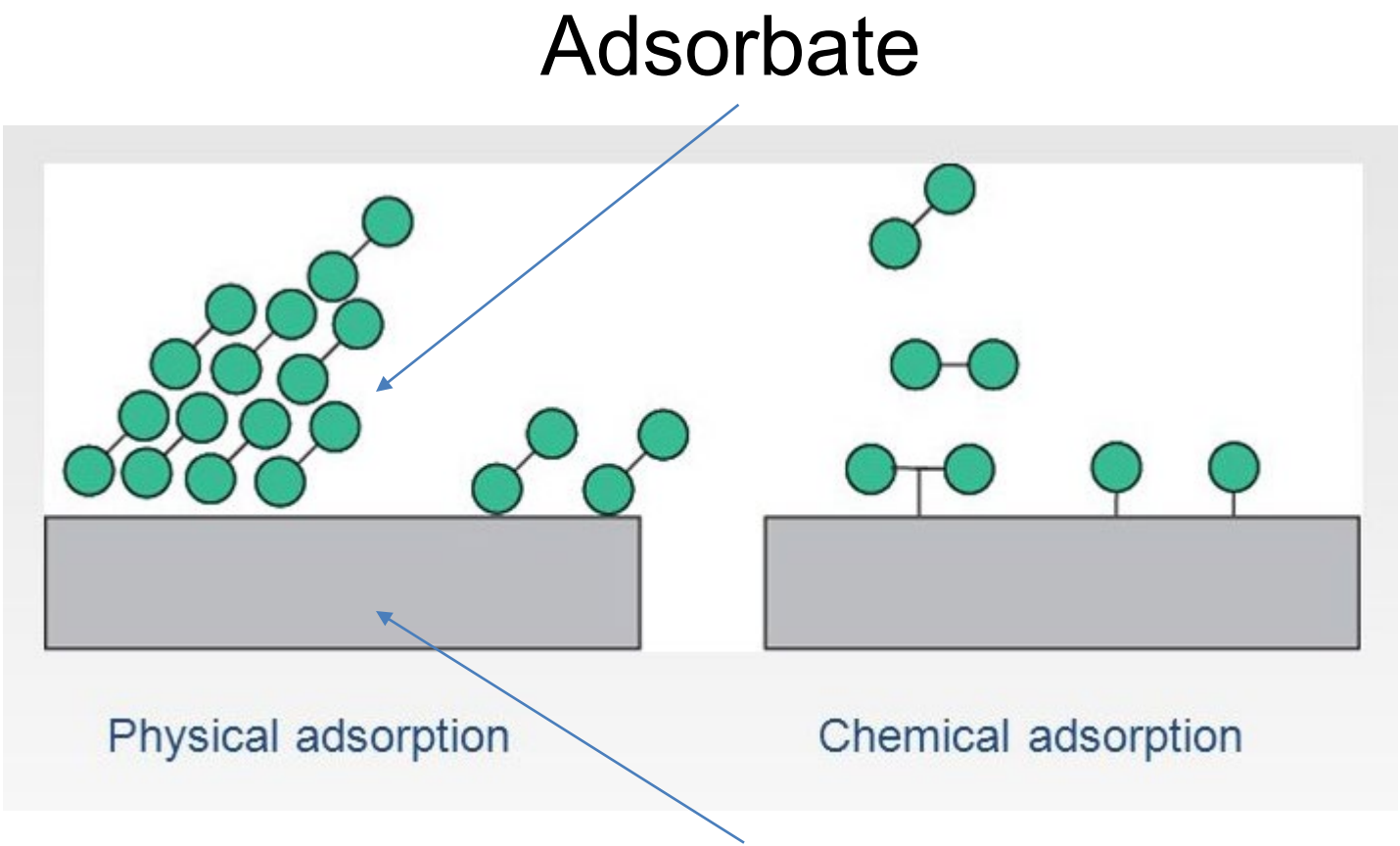


Particles of similar size can vary drastically in surface area

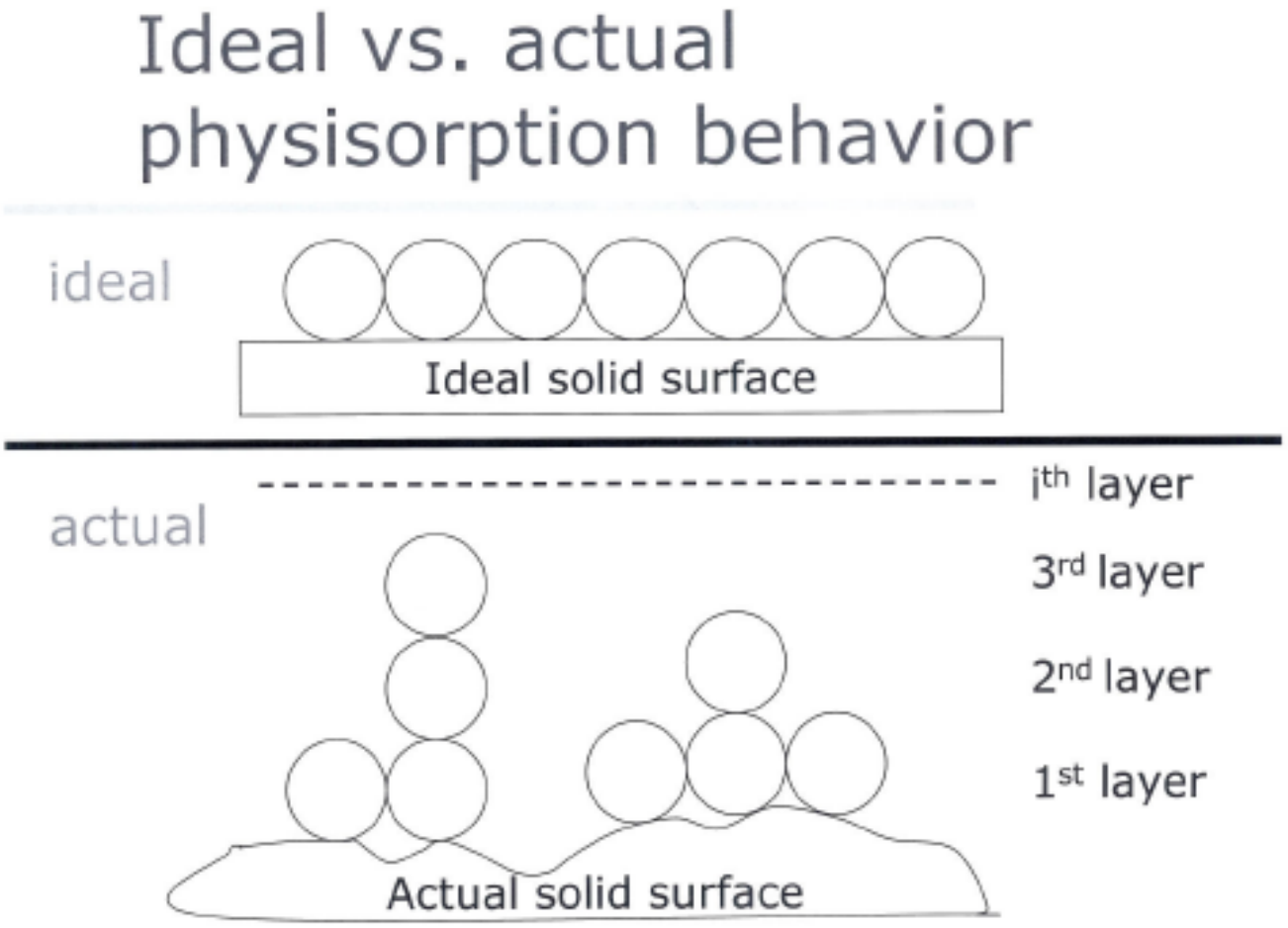




Physical adsorption occurs due to Van der Waals forces when at low temperatures and without chemical reactions



BET Theory extends the Langmuir theory from monolayer adsorption to multilayer adsorption



We use the BET equation to determine the monolayer absorbed gas volume (v_m)

$$\frac{1}{v[(p_0/p)-1]} = \frac{c-1}{v_m c}\left(\frac{p}{p_0}\right) + \frac{1}{v_m c}$$

v = adsorbed gas quantity

p_0 = saturation pressure of adsorbate

p = equilibrium pressure of adsorbate

c = BET constant = $\exp\left(\frac{E_1 - E_L}{RT}\right)$

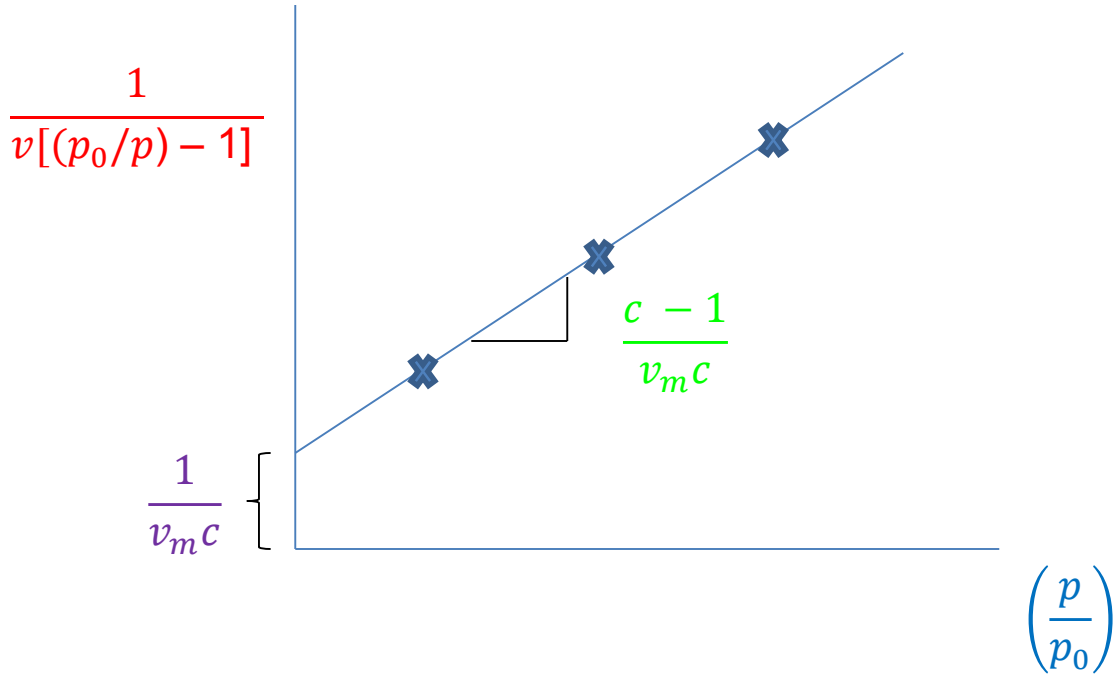
E_1 = heat of adsorption for the first layer

E_L = heat of vaporization

BET equation can be plotted to determine monolayer adsorbed gas quantity and the BET constant

$$\frac{1}{v[(p_0/p)-1]} = \frac{c-1}{v_m c}\left(\frac{p}{p_0}\right) + \frac{1}{v_m c}$$

$$y = mx + b$$



Take numerical values for slope and intercept to solve for v_m and c

$$slope = \frac{c - 1}{v_m c}$$

$$\text{intercept} = \frac{1}{v_m c}$$

$$v_m = \frac{1}{slope + intercept}$$

$$c = 1 + \frac{slope}{intercept}$$

From the monolayer absorbed gas volume (v_m), we can determine total and specific surface area

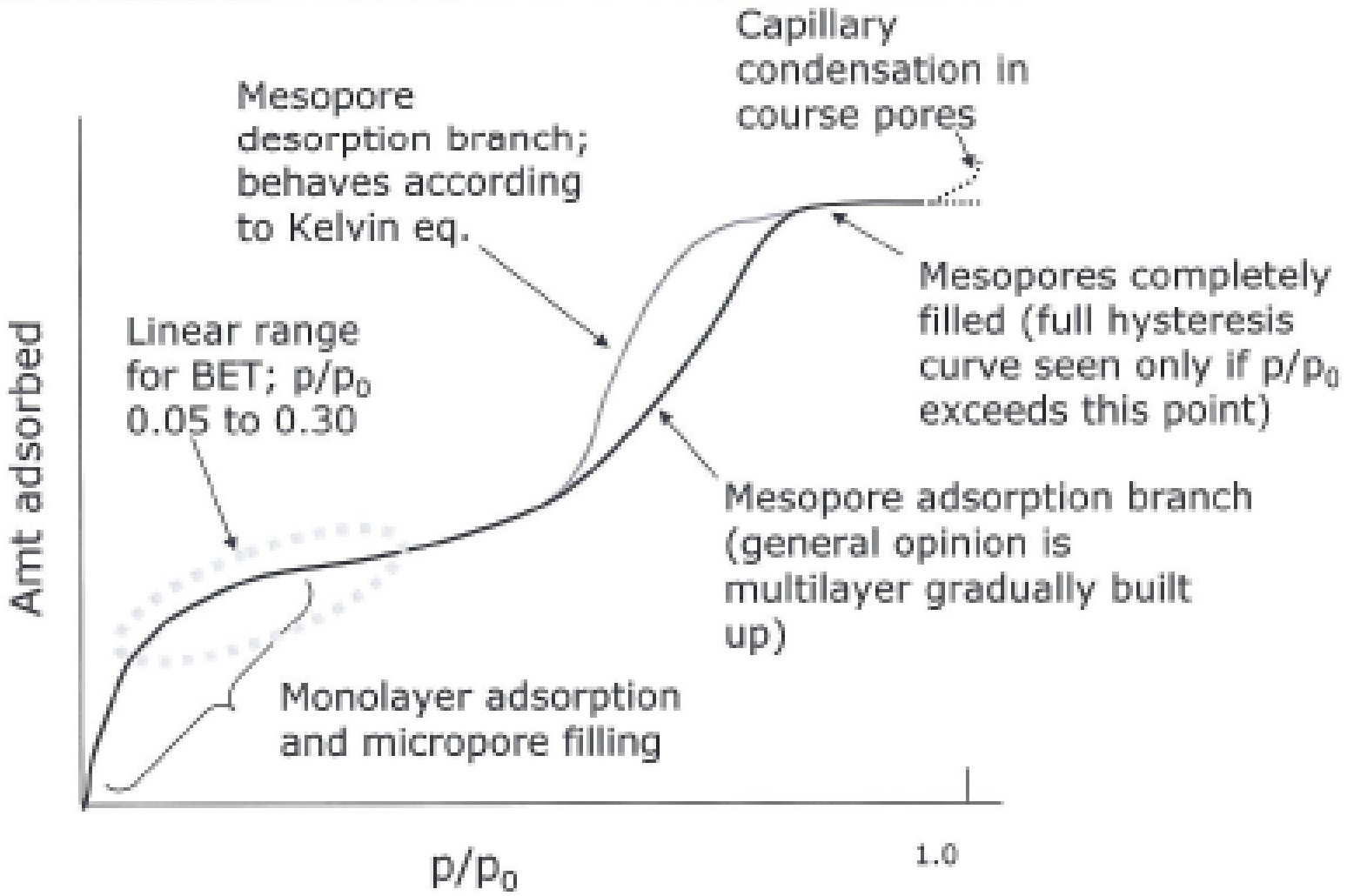
$$S_t = \frac{v_m N s}{V}$$

S_t = total surface area of sample material
v_m = monolayer absorbed gas volume
N = Avogadro's number = 6.02 x 10^{23} molecules/mol
s = cross-sectional area of adsorbed gas molecule
V = molar volume of adsorbed gas

$$S_{BET} = \frac{S_t}{a} \text{ [=] } m^2/g$$

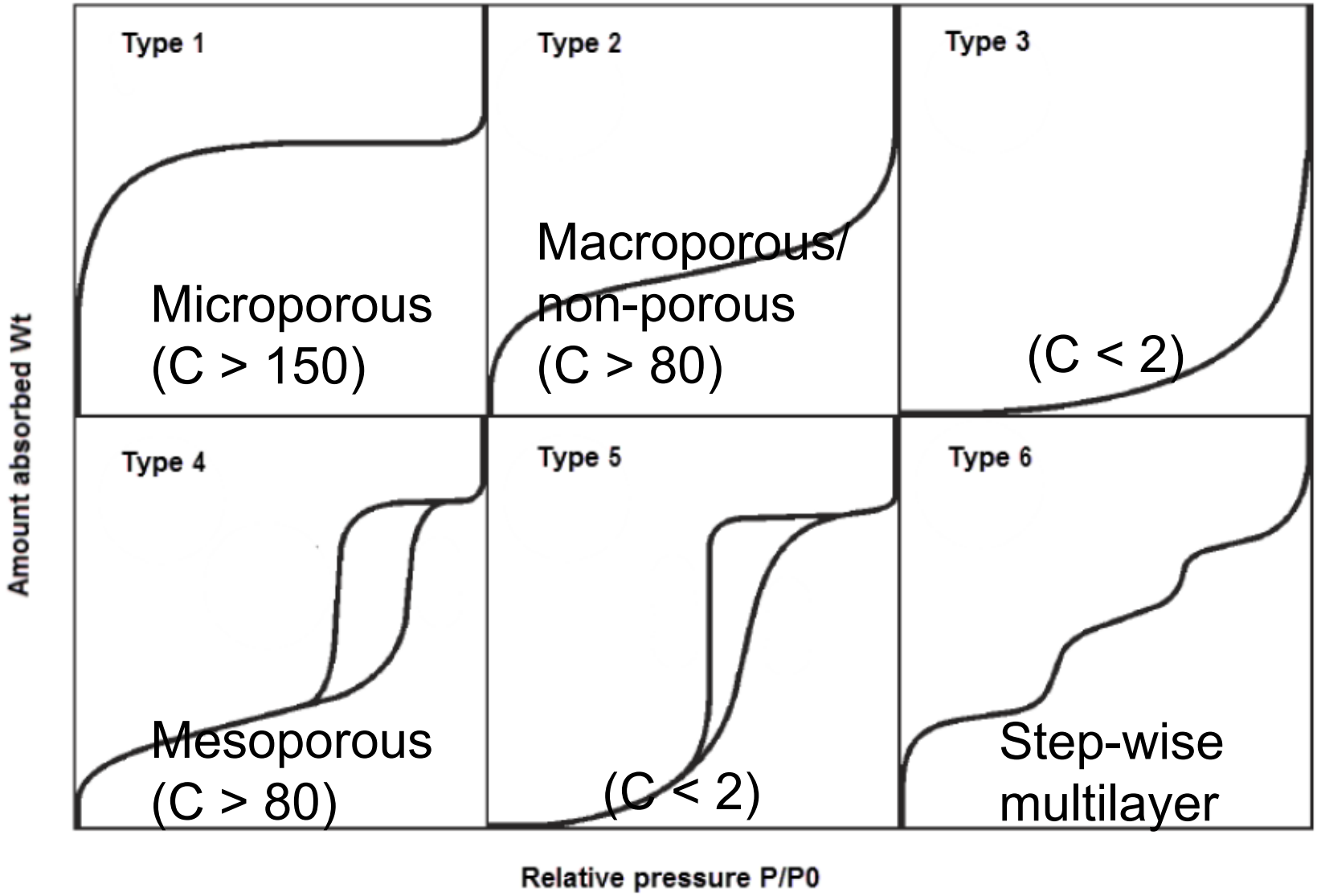
S_{BET} = specific surface area
a = mass of sample

Can only assume linear relationship for adsorption isotherms in the range of 0.05 < p/p_0 < 0.30

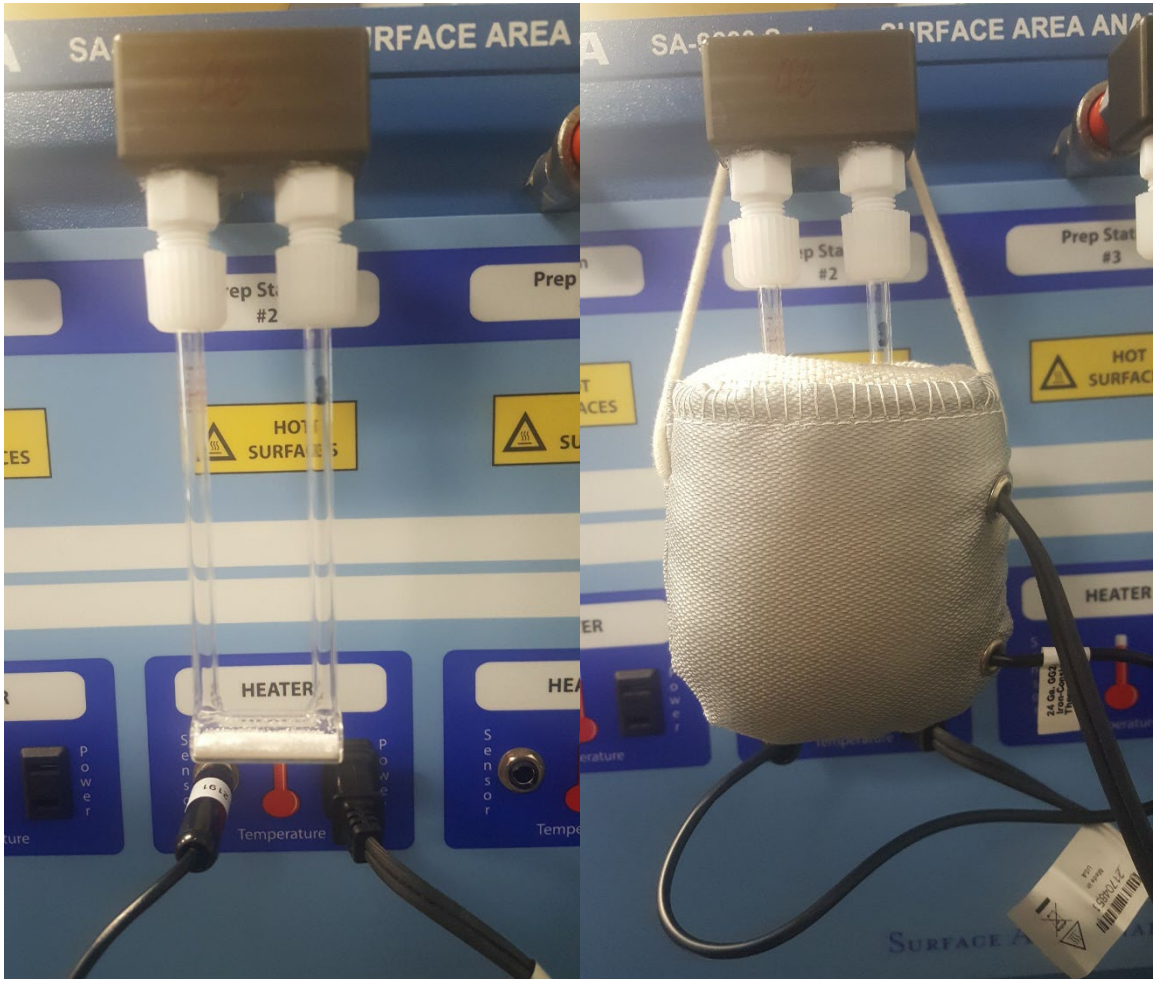


Pore width can make a big difference on shape of isotherm

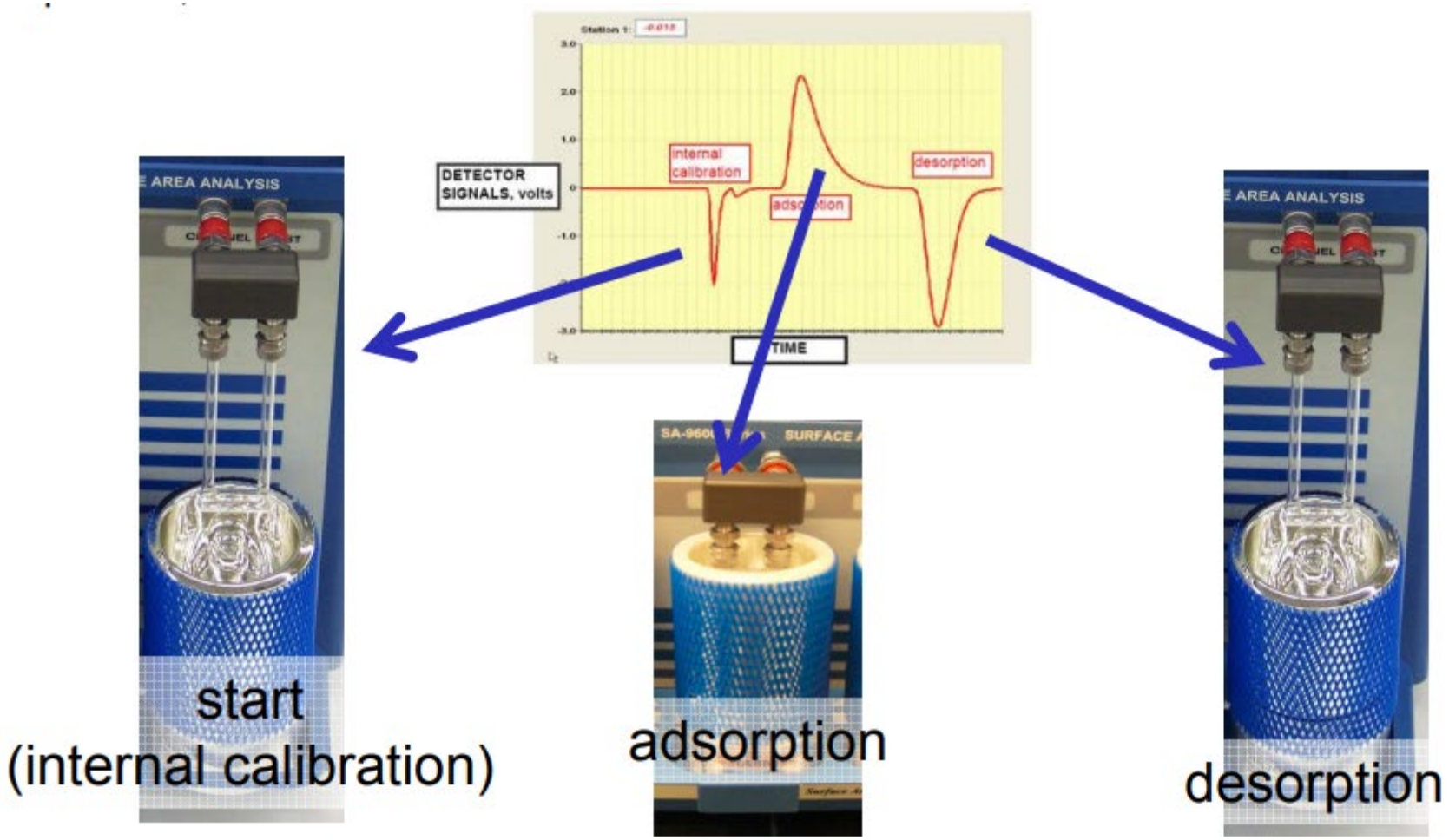
Usually apply BET theory to Type 2 and Type 4 isotherms, apply to Type 1 with caution



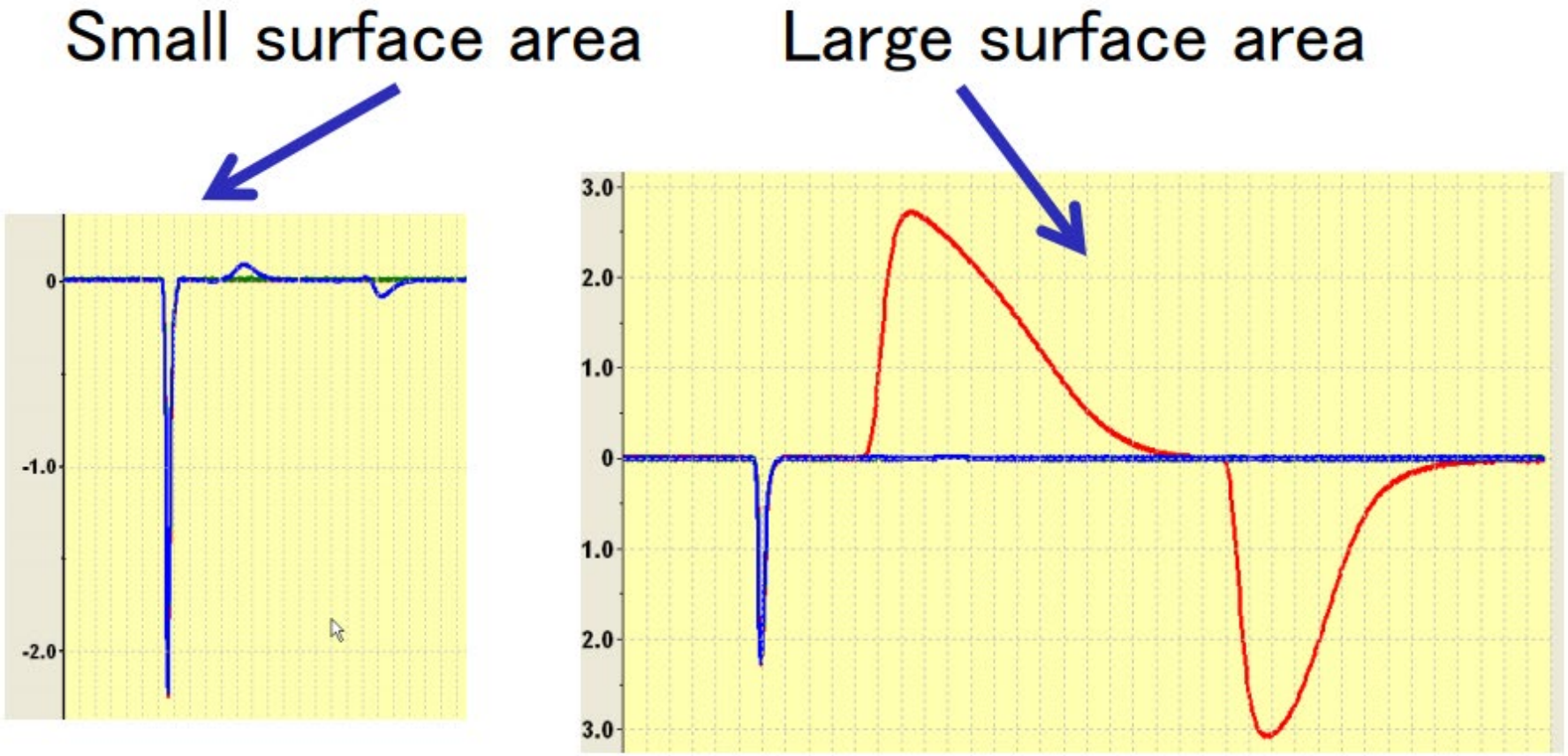
Have to insert sample into cell and degas sample to remove excess moisture on surface



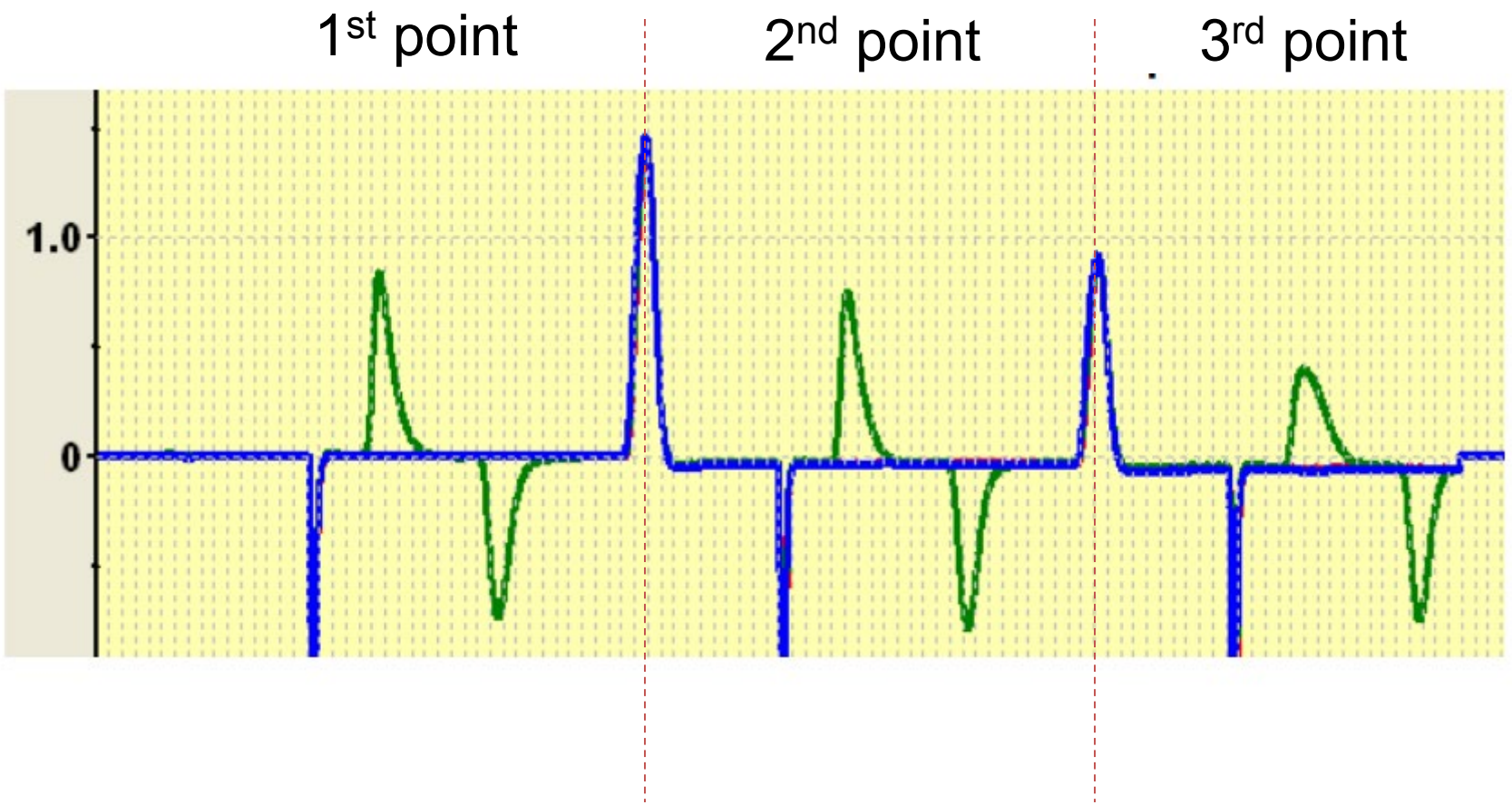
BET measurement includes calibration of 1 cm^3 of nitrogen, adsorption, and desorption



Large surface area samples will adsorb and desorb more nitrogen



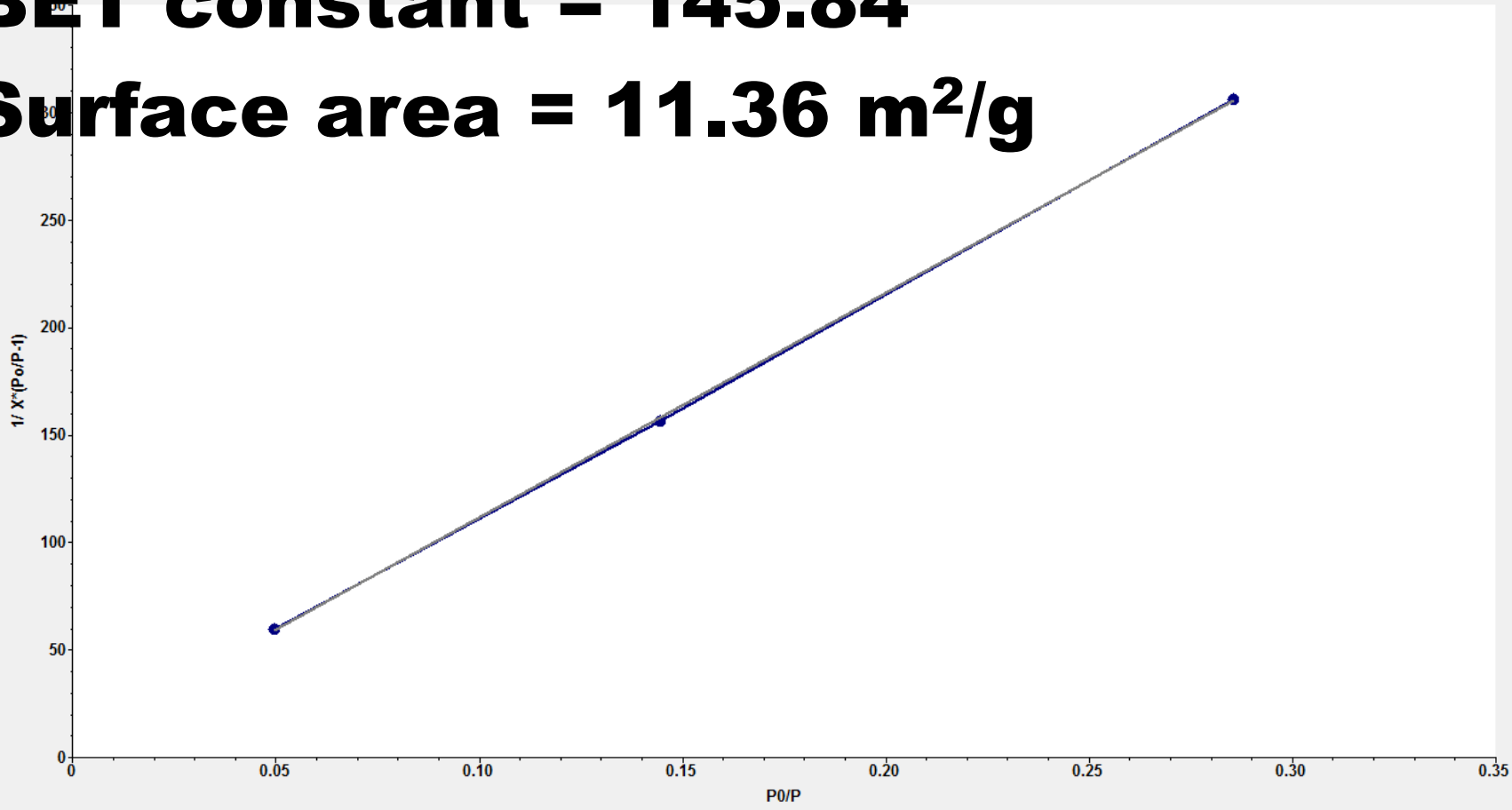
BET multipoint measurement example



Plot at least 3 points to obtain multi-point plot, solve for BET constant (c) and V_m (monolayer volume)

BET constant = 145.84

Surface area = 11.36 m^2/g



Thank you very much for your attention.

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