ROLE OF BOND ENERGY IN PRESENCE OF ADHESIVE FORCE

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Abstract— In this paper role of bond energy in the presence of adhesive force is presented. We have observed that along with the adhesive force, another minor force is existing between two compounds. It is due to bond energy. Here characteristics of water with different solid surfaces are observed, which gives the evidence of minor force, along with this we have also proved that it is due to bond energy.

Index Terms— Adhesive force, bond energy, contact angle, work of adhesion.

I. INTRODUCTION

On the basis of water, all the substances can be divided into two types- hydrophilic, which can easily attach with water and cause wetting [1] whereas other are hydrophobic, which does not wet easily [2]. Here we will deal with hydrophobic substances because the effect of bond energy can be easily observed in the case of hydrophobic substances (in our experiment).
This paper is arranged as follows-
Section II introduce about contact angle and work of adhesion, Section III presents two important observations, Section IV is the calculation for the bond energy of typical liquid drop, Section V gives the explanation and Section VI gives the conclusion.

II. DEFINITION OF SOME COMMON TERMS

A. Contact Angle

Contact angle (θ) may be defined as the angle at which liquid – solid, solid – vapor, or vapor – liquid interface meets [3].
When $0^{\circ} < \theta < 90^{\circ}$ then liquid – solid attraction is more than liquid – liquid attraction. It means the surface is hydrophilic i.e. the adhesive force is more whereas the cohesive force is less and in this condition water wets the surface. When $90^{\circ} \leq \theta \leq 180^{\circ}$ then liquid – solid attraction is less than liquid – liquid attraction i.e. the adhesive force is less whereas the cohesive force is more. It means the surface is hydrophobic and in this condition water takes the shape of a droplet [4].

B. Work of adhesion

Work of adhesion may be defined as the work done per unit area to separate two different surfaces (example- liquid and solid) from one another [5].

Fig.1 - cable (wire) with water drops

Fig. 2 – candle with water drops

By Young - Dupre Equation-

$$W = (1 + \cos\theta)\gamma \qquad (1)$$

Where- W = Work of adhesion, θ = contact angle, and γ = surface energy of the liquid [6].

III. EXPERIMENTAL OBSERVATIONS

A. Observation 1

Fig. 1 shows that when a water drop falls on a cable (wire), then it remains to stick with that cable (in downward position), and it can also bear appreciable disturbance (such as- movements, vibrations etc), whereas coating of wire or cable is made up of hydrophobic substances [2]-[7] and liquid – solid attraction is less than liquid – liquid attraction. So a question arises that, if liquid – solid attraction is less then, why does drop stick with cable, so strongly?

B. Observation 2

Fig. 2 shows that when water is fall on a candle (in place of a cable), then the same thing is observed, whereas candle is made up of hydrophobic substance (i.e. wax) [2]. So again the same question arises that, why does drop stick with the candle, so strongly?

IV. BOND ENERGY OF A TYPICAL WATER DROP

A. Area of water molecule

We can determine the molecular radius of the water molecule by interpolating effective ionic radii of isoelectronic ions O^{2-}, OH^{-} and H_3O^{+}.
The radius of water molecule is$1.375 \times 10^{-10} m$ [8].

As water molecule (H_2O) is of 'V' (bent) shape [9], so its area with minimum error can be calculated by assuming it a circle. This assumption will not affect our calculation adversely and error caused by it is very small so, can be taken as negligible.
Approximate area of water molecule (by πr^2)
$= 5.939 \times 10^{-20} m^2$ (2)

B. Number of water molecules in a typical drop

Raindrop size varies from $0.5 \times 10^{-3}\ m$ to $4 \times 10^{-3}\ m$ in diameter. So we can take-
The diameter of typical water drop
$= 2 \times 10^{-3}$[10]. (3)
(Here we are not taking liquid drop as a sphere but taking that as a circle because only circle part i.e. the base of drop touches the surface and here we are dealing with adhesive force). So, by solving (2) and (3) we can calculate-
Number of water molecule in typical drop $= 5.289 \times 10^{13}\ molecule.$ (4)

C. Number of moles in typical drop

We know that by Avogadro number-
1 mole = $6.02 \times 10^{23} molecules$ [11]. (5)
By (4) and (5) we can calculate-
Number of moles in typical water drop
$= 8.786 \times 10^{-11}\ moles$ (6)

D. Approximate minimum energy for typical drop

Let us assume that minimum bond energy
= 1 K.J/mol (7)
By (6) and (7) we can calculate -
Minimum energy in KJ = 8.786×10^{-11} K.J (8)

V. EXPLANATION

As in observation 1 and observation 2, the surface is hydrophobic (i.e. contact angle is much greater than 90°) so the adhesive force is very weak in this condition, but liquid remain to stick with the surface for a long time. This is due to bond energy because we know that bond energy exists between every bond and as we have seen in (8), minimum energy in every typical water drop is 8.786×10^{-11} K.J. So we can conclude that bond energy always remains almost constant in every case. This constant energy helps water drop to remain stick with the hydrophobic surface. But by (8), we can also see that- as bond energy increases, minimum energy gets decreases (due to the negative power of 10).

Thus this energy decreases with increase in strength of the bond. That is why its effect is negligible in the case of strong bonds i.e. in case of cohesive force.

CONCLUSION

By above explanation, it is clear that- bond energy helps to increase adhesive force, or in other words bond energy acts as the adhesive force, but its effect can be easily observed in the case of hydrophobic surface.
So, due to bond energy, a drop remains to stick with a hydrophobic surface.

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