Class - B.Sc. Part I (Subsidiary)

Subject - Chemistry

Paper - Subsidiary

Topic - Inductive effect

Name - Dr. Rashmi Sinha

Department of chemistry

H.D. Jain college, Ara

Inductive effect

The polarity developed between carbon and its substituent due to the difference in their negativity is known as Inductive effect.

This polarity development is due to the shifting of shared electron pair towards more electronegative atom.

The bond between carbon and Hydrogen has been assumed to be standard. When Hydrogen is replaced by an atom 'X' which is more electronegative then carbon.

Thus, X develop '$-\delta$' charge and carbon develop '$+\delta$' charge. on the otherhand when Hydrogen is replaced by an atom y which is less electronegative than

carbon. Thus y develop '+δ' charge and carbon develop '−δ' charge.

$$C - X$$

or $$C^{+\delta} \quad :X^{-\delta}$$

$$C - Y$$

or $$C:^{-\delta} \quad Y^{+\delta}$$

Thus, in this case X is said to be −δ effect and y is said to be +δ effect.

The group having −I effect are F, Cl, Br, I, NO_2, NO, C_6H_5

The group having +I effect are all alkyl group.

The substituents X pulls towards it the electron pair between α-carbon and X. This produce a slight positive charge (+δ) on the α-carbon. When a small positive charge is acquired by the α-carbon it will tends to attracts to itself the electron pair linking it with β-carbon. This causes β-carbon also to acquire a

fractional positive charge, which of course would be smaller than that of the α-carbon due to the decreasing influence of X. Similarly, the β-carbon influences the electron pair bonding it with γ-carbon, but to a lesser degree and still a smaller positive charge is developed on the γ-carbon. Denoting the decreasing magnitude of positive charge on α, β and γ carbon atoms by δ^+, $\delta\delta^+$ and $\delta\delta\delta^+$, the inductive effect relayed along the carbon chain may be represented as below.

$$\overset{\delta\delta\delta^+}{C} \rightarrow \overset{\delta\delta^+}{C} \rightarrow \overset{\delta^+}{C} \rightarrow \overset{\delta^-}{X}$$

with an electron-pumping substituent Y, the inductive effect will be reversed and the situation would be given as below :-

$$\overset{\delta\delta\delta^-}{C} \leftarrow \overset{\delta\delta^-}{C} \leftarrow \overset{\delta^-}{C} \leftarrow \overset{\delta^+}{Y}$$

Some common groups which cause -ve or +ve I-effect are given below in their decreasing order

-I effect gr.

$NO_2 > F > COOH > Cl > Br > I > OH > C_6H_5$

+I effect

$(CH_3)_3C- > (CH_3)_2CH- > CH_3CH_2- > CH_3-$

In general the inductive effect of the alkyl gr. is in the order $3^0 > 2^0 > 1^0$ groups. In other words the electron-releasing power of a Primary carbon (1^0) is less than that of a Secondary carbon, while that of a tertiary-carbon is the maximum. The inductive effect caused by the presence of an electron-attracting substituents relayed on a chain falls rapidly as the distance from the functional gr. increases.