DYLON INFORMATION SHEET
THE CHEMICAL STRUCTURE AND PROPERTIES OF DYES

To be of use, dyes must possess the following four properties: -

1. Colour
2. Solubility in water
3. Ability to be absorbed and retained by fibre (substantivity) or to be chemically combined with it (reactivity).
4. Fastness i.e. ability to withstand washing, dry cleaning and exposure to light.

In order for dyes to possess all of these properties simultaneously, the dye molecule must combine various groups of atoms into one structure.

The following comments illustrate, by reference to the structures of typical dyes, how the presence of certain groups determines the properties of the dye.

1. Colour

Organic dyes, whether natural or synthetic, are complex unsaturated compounds having certain substituent groups. The unsaturated part of the molecule is called the chromophore, which, ultimately, is responsible for the colour. In textile dyes, the chromophore usually consists of aromatic rings e.g. anthraquinone and triphenylmethane or Azo groups e.g. Azo benzene.

Although these chromophores do give characteristic colours, these colours tend to be very weak because most of the light they absorb is at wavelengths in the ultraviolet region, which is invisible. The final colour, however, is influenced by the presence of substituent groups known as auxochromes, which shift the wavelengths of the light absorbed into the visible region. Typical auxochromes are -CO, -OH and $-NH_2$.

The colour seen is not absorbed light, but reflected light. For example, Azo dyes tend to absorb light in the blue and violet region and so reflect light in the yellow, orange or red region. The dye is, therefore, coloured yellow, orange or red (depending on which auxochromes are present). Both anthraquinone and triphenylmethane absorb in the yellow / red region and so appear blue.

2. Solubility in water

Dyeing normally occurs in aqueous solution, so the dye must contain groups that make it soluble in water. These groups can be anionic (e.g. $-SO_3^{O}$ Na^{O}), cationic (e.g. $-NH_3^{O}$ $C1^{O}$) or non-ionic (e.g. -OH, $-NH_2$ or SO_2 NH_2). You will notice that some of these groups are also auxochromes and so influence the colour of the dye.

3. Ability to be absorbed and retained by fibre

Substantivity is the mutual attraction between the fibre and the dye. The presence of one or more specific group in a dye molecule determines its substantivity for a particular type of fibre. As this is a very complex subject, we will look only at the dyeing of cotton.

For a dye molecule to be substantive to cotton (or to be more accurate, cellulose) then it must have a conjugated chain (a chain of alternate single and double bonds).

The substantivity of the dye increases with an increasing number of conjugated bonds. To have any substantivity, a molecule requires at least 8 alternating bonds. Once the dye has been attracted to the cellulose, it is held in place by non-polar forces. These forces have the universal tendency of atoms or molecules to attract one another. This is especially true when the two molecules have certain characteristics in common. Cellulose consists of long and fairly flat molecules and so a cotton dye should also have a long, flat, planar molecule.

In addition to non-polar forces, one class of dye, known as “reactive” dyes, form a covalent bond with cellulose. This bond is much stronger and so the dye has better fastness.

The bond is formed by reaction between a specific part of the dye molecule and the many hydroxyl groups found in the cellulose molecule.

The main reactive groups used are triazine, pyrimidine and vinyl sulphone.

The type of reaction that occurs depends on the type of reactive group present, although in all cases an ether linkage is formed between the dye and cellulose.

4. Fastness

Reactive dyes, those covalently bonded to the fibre, have much greater washfastness than those only loosely bonded by non-polar forces.

The fastness to light is dependent on the structure of the dye and varies greatly from dye to dye. In general, Azo dyes have poorer lightfastness than anthraquinone or triphenylmethane dyes.