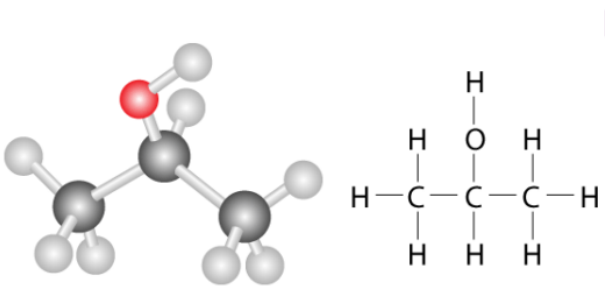
IMF's, Solubility, and Miscibility Lab

Background: A solid or gas that dissolves in a liquid is said to be soluble in that liquid and will form a homogeneous solution. Solubility reaches a limit when the solution is saturated. The term soluble is used in a general sense to describe if one substance (solids, liquids or gases) will mix with another substance to form a homogeneous solution.

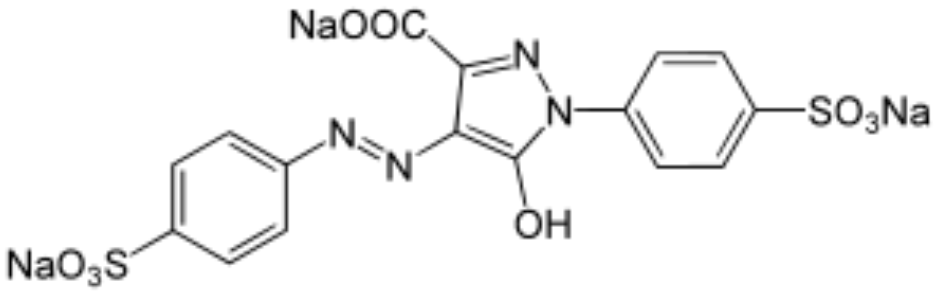
When two liquids dissolve in each other, they are defined as miscible and will mix in any proportion and will not reach a saturation point.

Solubility and miscibility are determined by a variety of factors. In general "like dissolves like" and molecules that are similar in polarity, size, shape and have similar IMFs tend to mix with each other.

Propan-2-ol or 2-propanol (isopropyl alcohol, density ~ 0.785 g/mL) is widely used as an antiseptic.

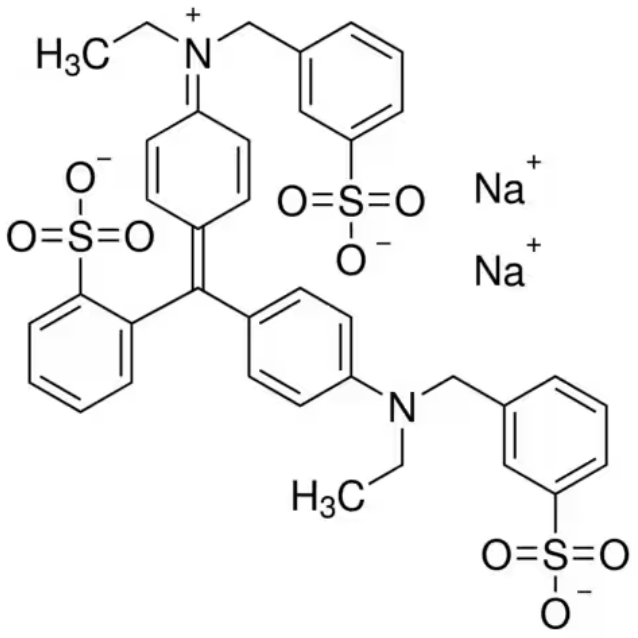


Tartrazine is a synthetic lemon yellow azo dye primarily used as a food coloring. It is also known as E number E102, C.I. 19140, FD&C Yellow 5, Yellow 5 Lake, Acid Yellow 23, Food Yellow 4, and trisodium 1-(4-sulfonatophenyl)-4-(4-sulfonatophenylazo)-5-pyrazolone-3-carboxylate).

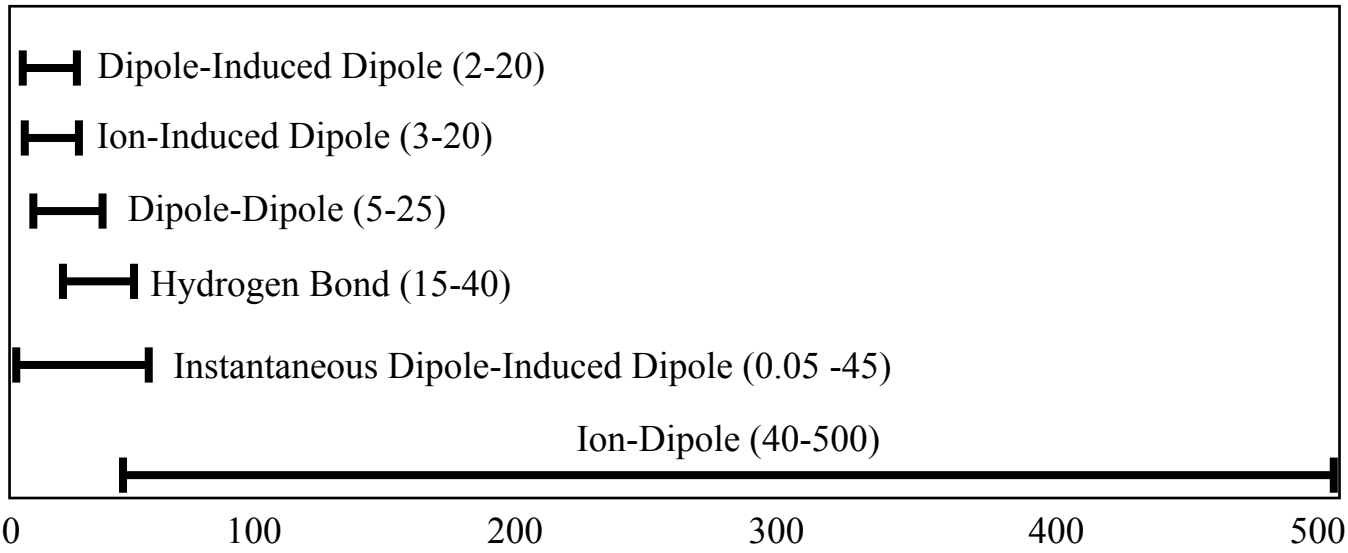


Azo compounds compounds contain the C-N=N-C linkage. Azo dyes are synthetic dyes and do not occur naturally. Azo dyes comprise 60-70% of all dyes used in food and textile industries.

Brilliant Blue FCF (Blue 1) is a synthetic organic compound used primarily as a blue colorant for processed foods, medications, dietary supplements, and cosmetics. It is classified as a triarylmethane dye and is known under various names, such as FD&C Blue No. 1 or acid blue 9 or disodium;2-[[4-[ethyl-[(3-sulfonatophenyl)methyl]amino] phenyl]-[4-[ethyl-[(3-sulfonatophenyl) methyl] azaniumylidene]cyclohexa-2,5-dien-1-ylidene]methyl]benzenesulfonate.



Intermolecular Forces Strengths (kJ/mol)



Materials: 30 mL vial, 10.0 mL graduated cylinder, green food color, distilled water, 91% isopropyl alcohol, vial rack, molecular models: 7O, 7C, 6 two hole H, 14 one hole H, 2K, 8 single bonds, 2 double bonds, 16 lone pairs (with H bonding).

Procedure:

1. Measure 10.0 mL of distilled water into a clean, dry vial.
2. Measure 10.0 mL of 91% Isopropyl alcohol into the same vial.
3. Place the plastic seal and lid on the vial and invert several times to mix. Observe. Set the vial in the plastic stand.
4. Add 1 drop of green food color to the vial. Place the plastic seal and lid on the vial and invert several times to mix. Observe.

5. Measure 7.0 mL of saturated potassium carbonate solution and place it in the vial. Place the plastic seal and lid on the vial and invert several times to mix. Place the vial in the rack and observe.
6. Make two models of propan-2-ol and two models of water. Demonstrate IMFs between propan-2-ol and propan-2-ol, water and water, and propan-2-ol and water.
7. Make a model of the carbonate ion and two potassium ions.
8. Using the models, make a stop motion movie (or demonstrate the process to the instructor) demonstrating the process that took place in the vial.

Observations:

Analysis:

1. What IMFs exist between a water molecule and propan-2-ol molecule?

2. What IMFs exist between a water molecule, yellow 5, and blue 1?

3. What IMFs exist between propan-2-ol, yellow 5, and blue 1?

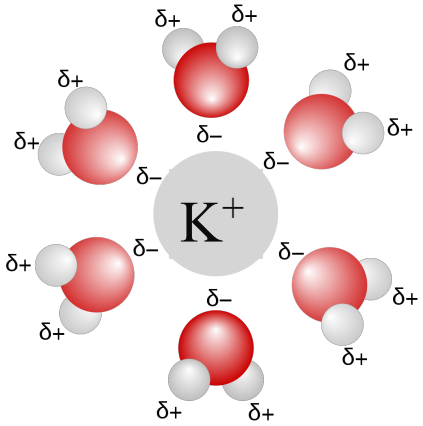
4. What IMFs exist between a water molecule and a potassium ion? Draw a particulate diagram with at least four water molecules and a potassium ion (include charges and partial charges, lone pairs are optional).

5. What IMFs exist between a water molecule and a carbonate ion? Draw a particulate diagram with at least four water molecules and a carbonate ion (include charges and partial charges, lone pairs are optional).

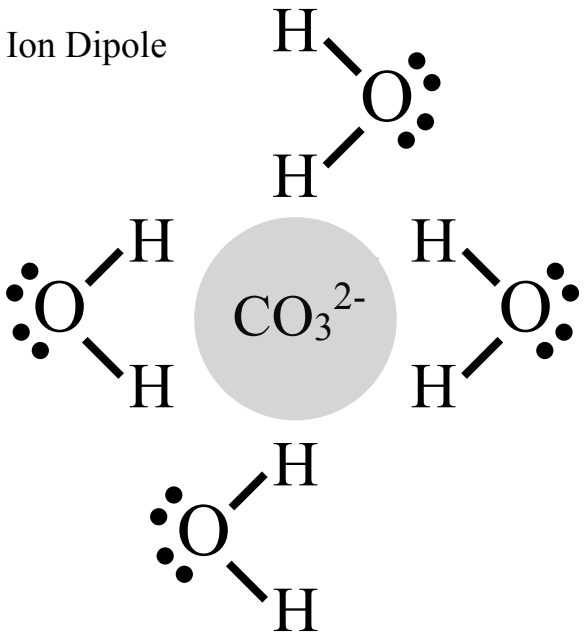
6. Explain (at the molecular level) what you think happened when the potassium carbonate solution was added to the vial. Include any color changes.

Answers:

1. LDFs, DDs and H-bonds
2. LDFs, DDs and H-bonds
3. LDFs, DDs and H-bonds
4. Ion dipole



5. Ion Dipole



6. When the saturated potassium carbonate solution is added to the mixture of water and propan-2-ol and food color, the potassium ions and carbonate ions attract water molecules more strongly than the alcohol, yellow 5 or blue 1 (compare ion-dipole to H-bond strength) causing the alcohol to release the water and H-bond to other alcohol molecules and the blue 1 molecules. The yellow 5 molecules may be more polar and have more hydrogen bonding than the blue 1molecules. Higher entropy of the products and lower Free Energy of the products also determine the results.