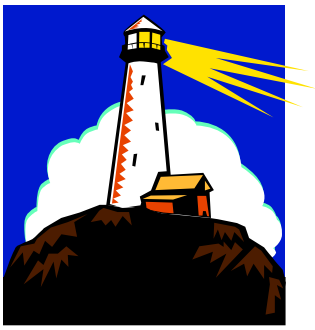

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Kauri-Butanol Values and Solubility Parameters

In the last Technically Speaking article on vapor degreasing I briefly mentioned the term Kauri-Butanol Value, which I related to solvent power. I want to take a little time to talk more about KB values and how they are used with regard to Chemtronics solvent-based cleaners. Then I'll touch briefly on the more complex topic of solubility and the uses of some of the different solubility scales.

When we talk about solubility with regard to chemicals we are usually referring to dissolving a small amount of a liquid or solid, the **solute**, in a larger volume of liquid, called the **solvent**. When a liquid solvent dissolves a solute the molecules of the solvent break the **electrostatic or binding forces** that bind the molecules of the solute together. Solvent molecules force themselves between and around the solute molecules, until the molecules that made up the solute are finely dispersed within the larger volume of solvent molecules.

The KB or Kauri-Butanol value is a test that the ability of a **hydrocarbon** solvent to overcome these binding forces in a standard solute. The KB test is one of a number of "cloud-point" determinations that can be used to order solvents in a ranking based on relative solvent power. Other cloud-point determinations are aniline cloud-point, solubility grade, wax number, and heptane number. All have their specific uses but the KB value is the most widely used test for gauging the relative solvent power of most hydrocarbon solvents. Kauri resin is a fossilized resin derived from the sap of the Kauri pine tree, which grows primarily in New Zealand. This resin dissolves easily in normal butyl alcohol (butanol) but will not dissolve very well in hydrocarbon solvents. To run the KB one dissolves 20 grams of the Kauri resin in a fixed amount of n-butanol. This solution is then titrated with the hydrocarbon solvent to a "cloud-point" or until the clear solution first turns slightly turbid or hazy. To make the cloud point easier to see the test is usually performed over a page of ten-point type. When the ten-point type becomes slightly blurred or not quite crystal clear you have reached the cloud-point. The volume or number of milliliters of hydrocarbon solvent used to reach the cloud-point is reported as the Kauri-Butanol or KB value of the hydrocarbon solvent. By this methodology the greater the volume of solvent needed to reach the cloud-point, the "stronger" the hydrocarbon solvent. A solvent with a KB value of 100 (ml) is a much stronger solvent than one with a KB value of 50.

Tables of KB values for hydrocarbon solvents can be found in chemical handbooks and on the Internet. From these tables one can see that methylene chloride has a KB value of 136, while toluene has a KB value of 105, making toluene a weaker solvent than methylene chloride. Naphtha, which we use in ES2425 Pow-R-Wash Cable cleaner, and kerosene have the same relative solvent power with KBs of 34. The KB values for Chemtronics solvent cleaners, which are mixtures of various hydrocarbon solvents, are determined by running the Kauri-Butanol titration with the cleaner product or by estimating the KB value of the blended product from the KB values of its individual solvent components and their proportions in the mixture. We list the

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KB values for most of our solvent cleaners on the product technical data sheet. Most of the Chemtronics solvent cleaner blends have KB values of 50 or less, but the stronger aggressive products like Electro-Wash NXO, or Flux-Off Heavy Duty have KB values above 100. The higher the KB value of a Chemtronics cleaner the more likely it is that this product will attack soft plastics like polystyrene and polycarbonate. You would normally select a Chemtronics cleaner with a high KB value only if you need heavy duty cleaning of thick or encrusted residues and have no plastics in the application. If only light duty cleaning or plastic safety is required then select a Chemtronics cleaner that has a KB value of 50 or less.

Kauri-Butanol values are not the last word in solubility tests. In fact KB values tend to assign a higher solubility to a solvent than it really has. Also certain kinds of solvents cannot be tested with the Kauri-Butanol protocol as they prove to be infinitely soluble in this test procedure. For this reason ketones like acetone and MEK and glycol ethers cannot be tested by the Kauri-Butanol procedure to determine these solvents solubility. Though KB values can give misleading results for many solvents, it still proves useful when used to judge the relative solubility of different solvents.

Kauri-Butanol value is only a small part of the subject of solubility and there are many different solubility scales.
The most commonly used solubility scale is the **Hildebrand solubility parameter**. All the electrostatic forces that bind the molecules of a liquid or solid together represent that substance's **cohesive energy density**. This sum of these binding forces is what has to be overcome to either dissolve a substance in a solvent or to vaporize the substance completely by heating it to dryness. The Hildebrand solubility parameter (the square root of the cohesive energy density) is a numerical representation of this quantity of energy, usually expressed as calories/cubic centimeter or in standard international units (SI) as mega-pascals of cohesive pressure, required to overcome all of these binding forces when a substance is dissolved or evaporate to dryness. Even the Hildebrand solubility parameter can be represented as the sum of three separate Hansen solubility parameters, each of which is a measure of one of the three electro-static forces (dispersion, polarity and hydrogen bonding) that bind molecules together.

The three Hansen parameters can be plotted in a three-dimensional graph and this graph can be used to predict the solubility behavior of different solvent systems with a high degree of accuracy. But three-dimensional graphs are hard to use and not portable. Plotting the three parameters on a two dimensional graph by ignoring one of the three parameters is a partial solution but looses accuracy with regard to the 3D graph as one of the parameters is missing. A solution to this problem was found when a two-dimensional triangular graph was developed that plotted the Teas **fractional parameters**, derived from the Hansen parameters. The Teas parameters show the percent contribution each of the three binding forces make to the whole Hildebrand parameter. When the position of individual solvents is plotted on a Teas graph we find that solvents with similar solubilities tend to occupy the same area of the graph. We can

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also plot the solubility of a particular resin or polymer with various solvents and determine for that substance a solubility window. Those solvents that dissolve the polymer fall within the area of the Teas graph defined as the solubility window; those that partially dissolve the polymer fall on the edge of the solubility window area; those that do not dissolve the polymer fall outside the area of the graph defined as the solubility window.

This is all probably confusing, but the main point is that using a TEAS graph one can determine the solubility properties of solvent blends without actually making up the blend and testing it. One can also use such a tool to determine the composition of a solvent blend that will dissolve one particular substance in a mixture without dissolving any of the other substances present. Further, the Teas graph and the other solubility scales can be used **without** having any knowledge of the complex chemistry and physics involved in polymer and resin solubility. Workers who restore valuable artwork use the Teas graph to determine the solvent system required to remove overlying layers of aged lacquer without dissolving the underlying paint that makes up the masterpiece. Such tools as the Teas graph are invaluable in determining the solvent system required to dissolve the many polymers used in industry today. A simple knowledge of these tools can solve practical everyday problems without recourse to more complex information regarding the solvents being considered.

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