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IPA As A Universal Cleaner: Advantages and Disadvantages

Isopropyl alcohol (IPA) has become a standard in the Electronics Industry for cleaning printed circuit boards (PCBs) as it offers two main advantages: its cheap and it removes ionic contamination(as long as it's flushed from the surface). For years IPA has been used to remove flux residues after soldering and as a general cleaner to remove oil, grease and other handling soils. The polar nature of IPA does make it a fairly good cleaner for removing ionic salts from PCBs, and IPA will dissolve the organic acids in rosin-based soldering fluxes. In terms of expense it can be purchased in large bulk quantities at pennies per gallon and is readily available nationwide.

Outweighing these advantages are a host of disadvantages with respect to the use of IPA as a general cleaner for electronics. The polar nature of IPA makes it a poor cleaner for removing non-polar oil and grease. In the real world one usually encounters both polar ionic contaminants and non-polar oils and grease, so for the best cleaning one needs to use a cleaner that combines both the cleaning action derived of a polar solvent like IPA and a non-polar solvent to remove non-polar oils and grease. Purchased in bulk, the purity of IPA is not easy to guarantee, especially as the cost decreases. The flammability of IPA also presents safety issues.

Let's begin by looking at the various factors that effect IPA in terms of its solvent abilities. The ability of a solvent to dissolve another substance (the solute), lies in the solvents ability to surround each molecule of the solute with many solvent molecules. IPA is a polar solvent. The hydroxyl group of the IPA molecule has a slight separation of electrical charge, in effect giving it both a positive and negative end. The electrically charged "end" of the molecule will attract those soils that are composed of molecules or ions that are themselves electrically charged. Salts that contain positive sodium (Na+), calcium (Ca+), sulfate (SO_4^{+2}), or ammonium (NH_4^+) ions and/or negative ions like chlorine (Cl^-), bromine (Br^-) and fluorine (F^-) will be attracted to the positive or negative end of the IPA molecule, which facilitates the surrounding of the solute molecules by IPA solvent molecules.

But the organic molecules that make up oils, grease and other hydrocarbon residues are non-polar and have no positive or negative parts that can be attracted to the oppositely charged ends of the IPA molecule. Therefore IPA has little effect in dissolving such soils. Some oil and grease may be physically carried away when hit with a stream of IPA, but it's the force of the stream that knocks the residue away from the surface and not dissolution of the residue in the IPA solvent. Since real world cleaning situations involve removal of handling soils (oils and grease from skin) as well as ionic contaminants, one needs to use a non-polar hydrocarbon solvent to dissolve the oils and grease as well as a polar solvent to remove the salts.

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IPA also has a unique feature, which here we will consider to be a disadvantage, in that it is hygroscopic. Hygroscopic substances have the ability to absorb moisture (water) from the air. The hygroscopic nature of IPA is very pronounced. IPA exposed to the air will absorb moisture rapidly until it reaches an equilibrium value of 65% IPA to 35% water. Assemblies rinsed with straight IPA will take longer to dry as the IPA dries relatively fast, while the absorbed moisture dries much more slowly. If one is using a squeeze bottle or trigger sprayer for application, each pump stroke will draw moist air back into the container, increasing the amount of absorbed moisture that is sprayed onto the assembly with each new stroke. As working time progresses the drying time for the assembly increases as it takes longer and longer for the absorbed moisture to dry.

A further complication arises from spraying the assembly with water-laden IPA: water left on the board may be a source of corrosion or electrical leakage. This is especially of concern if one is cleaning a printed board with fine pitch components. Water has a very high surface tension which makes it cling tightly in narrow spaces, inhibiting its evaporation. If the board is not dried in an oven or treated with a dry gas duster to blow out any water trapped by surface tension between fine pitch traces, this water may not evaporate during normal air drying. This water could sit on the board for days and will inevitably lead to corrosion or electrical migration between the traces.

Given the hygroscopic nature of IPA, the storage conditions required to restrict its exposure to moisture, until the moment of delivery for cleaning, also presents a problem. To lessen expense IPA is usually purchased in large bulk containers (bottles, cans or drums) but for ease of application IPA is usually used in plastic or metal containers equipped with a piston pump sprayer. Filling the pump spray containers from a bulk package offers another opportunity to expose the IPA to atmospheric moisture. Once in the pump container each activation of the piston pump expels air from the container and pulls in moister outside air which further dilutes the IPA. IPA not placed in a sealed container for use, but left exposed to the open air collects water vapor even faster. The best way to purchase and store IPA to prevent dilution by atmospheric moisture is to purchase it in aerosol containers. Aerosol packaging maintains a positive internal pressure that does not permit the introduction of outside air and water vapor into the container during use.

Other concerns relate to the purity of the IPA used. The attractive price of IPA in many cases is due to the fact that technical grades of IPA are being using for circuit board cleaning and general equipment cleaning. Technical grades of IPA may contain higher amounts of water and other contaminants like oil. This water and contaminating oil are therefore deposited onto the assembles being cleaned and only add to the cleaning problem. This is definitely a case of “you get what you pay for”; lower cost usually means lower quality. Less costly grades if IPA can also contain ionic contaminants. Using technical grade IPA can introduce ionic contamination

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to the circuit board rather than removing the ionic contaminants already present, as well as adding excess moisture. These added ionics can lead to electrical discharge between the traces if not rinsed away using a “cleaner” grade of IPA or other cleaning solvent that is free of ionic contaminants. Over time ionic contamination on the board will lead to corrosion and eventual board failure.

It has also been found that IPA tends to dry out some flux residues on contact. IPA-soluble ionic molecules and other polar species are dissolved while the non-polar constituents of the reside are left behind in a desiccated state. This causes the remaining residue to harden and cling more tenaciously to the circuit board. Such residues are harder to remove, taking a greater volume of IPA to do the job. Some scrubbing may also be required to completely remove the hardened residue, adding additional time and cost to the cleaning operation.

IPA can also damage some soft plastics. Exposure of some painted plastic surfaces to IPA can lead to fading of the paint color and also cause the formation of very fine cracks in the plastic surface, an effect referred to as crazing. IPA has been found to cause fading and slight crazing in some painted plastics which are currently being used in the new LCD and plasma televisions.

Plastic films used as anti-glare coatings on computer monitor screens can be especially sensitive to even mild alcohol dilutions. The alcohol cleaner will usually cause the anti-glare film to turn cloudy, rendering the monitor unusable. In these cases the monitor must be repaired by a professional or discarded. When selecting a cleaner to use to clean a monitor screen one should read the owner’s manual for the manufacturer’s recommendations or consult the monitor manufacturer directly for instructions on what to use to properly clean the monitor screen. In many cases solvent-based cleaners are not recommended.

In summary IPA has one primary advantage as a universal cleaner and that is its low cost. This cost advantage is greatly outweighed by numerous disadvantages: its inability to dissolve non-polar contaminants; its tendency to absorb atmospheric moisture which dilutes the cleaning power of the solvent and can lead to corrosion and electrical leakage when left on precision assemblies; its flammability; its deleterious effects of soft plastics, paints and polymer films; the complications presented in its handling and storage to maintain restricted exposure to atmospheric moisture; and problems with the quality of the product versus its cost. Because of the negative factors inherent in using straight IPA it makes more sense, when meeting the challenges of real-world cleaning situations, to use products that are blended from high quality polar and non-polar solvents, and are packaged to minimize moisture contamination.

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