Case Study 8 – Isopropyl Alcohol Purification Process

As an employee of a large corporation, this consultant was assigned to a technical support position of an operating isopropanol manufacturing facility. The process was based on well-known technology using sulfuric acid to indirectly hydrate propylene to produce isopropanol. Even though the technology was old and more expensive to operate (due to the usage and concentration of 70% sulfuric acid, a very corrosive concentration) versus the more modern direct hydration technology, the plant continued to operate profitably because the propylene feedstock was insensitive to the amount of propane in the feed (as opposed to the direct hydration technology, which required nearly pure propylene feed to be economically viable). Therefore, low value propylene streams (from the refinery FCC or depropanizer bottoms from the olefins plant) could be fed to this isopropanol unit with very little economic penalty. With some of these low value streams came other impurities like mercaptans and sulfides that would routinely cause odor problems for the finished isopropanol (acceptable odor was a finished product specification). Oligomerization of propylene in the sulfuric acid process was also very common, causing isopropanol purity and odor issues.

The indirect hydration isopropanol process also produces a major byproduct called diisopropyl ether. About 5 wt% to 10 wt% of the propylene is converted to diisopropyl ether. This ether is mostly insoluble in water (as opposed to isopropanol, which is infinitely soluble in water), forming a second liquid phase at certain isopropanol/diisopropyl ether/water concentrations as described by the following ternary diagram:

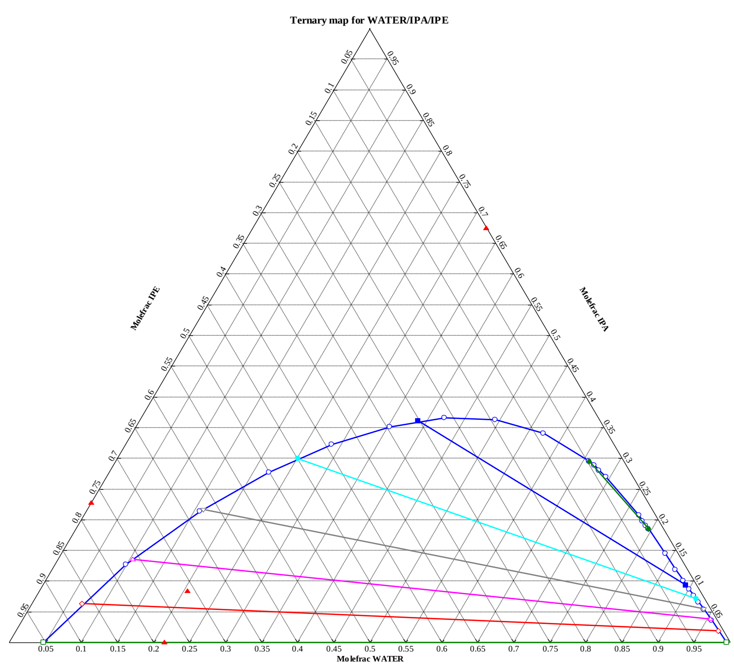

Figure 1 - Rough estimate based on VLE interaction parameters at atmospheric pressure

This consultant determined via process modeling that if the crude reactor product (a mixture of isopropanol, diisopropyl ether, and water (along with the impurities described above) is diluted further with recycle process water at an elevated temperature, two liquid phases will form (roughly according to the phase diagram above). Determined experimentally with the help of the plant chemist, the sulfur and oligomer impurities were found to distribute predominantly to the diisopropyl ether (light) phase, thereby separating the odor compounds from the crude isopropanol product and virtually eliminating the odor in the finished isopropanol product.

This consultant then designed and installed a large scale version of this phase separation process in the isopropanol purification process using an existing, idle horizontal storage cylinder (used to store butane in a previous process) to provide the phase and decanting control. The phase separation process successfully eliminated all future odor issues of the finished isopropanol product, regardless of the source of the propylene (allowing even greater flexibility in feeding low grade propylene streams). The process was also issued a patent.