



Isononyl Alcohol (INA)

Isononanol, also known as Isononyl Alcohol or INA for short, has been a commercially manufactured chemical product since the 1940's.

Its value is to the plasticizer market as a precursor to Diisononyl Phthalate (DINP), Diisononyl Adipate (DINA), and Triisononyl Trimellitate (TINTM). Primarily used in the PVC market, products made from INA can be found in automotive parts, electrical wires, cables, conducting materials and numerous other products.

As with most oxo alcohols, the origins of INA production can be traced back to the high-pressure cobalt process developed by German chemist Otto Roelen. Not surprisingly, the deficiencies of this process as observed in more commonly produced oxo alcohols is present with INA as well: (1) the process is capital intensive due to the need for high pressure equipment; (2) the high process temperatures generate significant levels of byproducts; and (3) there is a substantial waste footprint due to the high usage rate of cobalt catalyst.

In the 1970's, the LP OxoSM Process utilizing a rhodium-based catalyst for producing butyraldehydes was developed and is today licensed by Johnson Matthey Davy Technologies Limited (JM Davy) and Dow Global Technologies LLC (DGTL), an affiliate of Univation Technologies, LLC. Lower pressures and temperatures along with significantly lower quantities of catalyst usage rendered the high-pressure cobalt oxo process obsolete, except for situations involving higher chain olefins that could not

be effectively hydroformylated using the rhodium catalyst that was developed. Over the subsequent years, LP OxoSM Process was adopted as the preferred route for producing aldehydes from propylene.

Today, the majority of all licensed propylene-based oxo capacity utilizes the LP OxoSM Process. The benefits of the low-pressure process lead to substantial efforts in developing an effective rhodium modified catalyst that could hydroformylate octene isomers and other higher chain olefins.

Early commercial rhodium-based INA processes did little to improve upon the high temperatures and high pressures of the historical cobalt process. Attempts to operate at lower pressures resulted in catalyst instability, while catalyst activity was sacrificed at reduced temperatures.

In more recent years, DGTL and JM Davy have collaborated to develop an INA process that combines the production capabilities of historical cobalt-based processes with the economic benefits associated with our LP OxoSM Technology. In addition to meeting the "Four S's" of catalyst performance (Speed, Selectivity, Stability, Separation), the proprietary ligand used in the LP OxoSM INA Process yields a final product from mixed octenes, typically from a butene dimerization process, that is comparable to that which is produced by existing commercial manufacturers of INA. Overall operating costs associated with the LP OxoSM INA Process are lower than other commercially available INA processes.

Shown below (Figure 1) is a flow diagram of the LP OxoSM INA Process. The backbone of the flowsheet relies upon nearly 50 years of past development experience between both DGTL and JM Davy in the arena of low pressure hydroformylation technologies. The flowsheet also incorporates JM Davy's proprietary Liquid Phase Hydrogenation (LPH) scheme, which offers capital savings over a traditional Vapor Phase Hydrogenation (VPH) system, reduced operating costs, lower plot footprint and has been successfully employed for production of other alcohols in numerous facilities worldwide.

Choosing between the various plasticizer alcohols (INA, 2-Propyl Heptanol (2-PH) and 2-Ethyl Hexanol (2-EH)) involves many complex decisions, but some considerations that can make INA the more favorable choice are as follows:

- If the octene isomer feedstock is readily available, flowsheet simplification and an overall reduction in capital can be observed in the INA process as the need for a butene dimerization process can be eliminated.
- INA does not require capital for the aldolization step associated with other plasticizer alcohol processes, and subsequently there is a lower environmental impact as aldol wastewater effluent is not produced.
- Unlike 2-EH, there is no need for aldehyde isomer separation after the LP OxoSM Process. This saves capital and also directs all the aldehyde toward the desired final product.

