BY DAVID WEDLOCK

Uninhibited Base Oils

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We sometimes talk about "inhibited" and "uninhibited" base oils in certain lubricant applications. It is worth being clear what this means. Simply put, an inhibitor is another term for an antioxidant in a lubricant.

All hydrocarbon base oils require some level of antioxidancy buffer to provide a reasonable length service life. Even the best base stocks, such as API Group III and Group IV, would have unacceptably short service lives in high-temperature or oxidizing environments without some level of added antioxidancy.

Oxidation leads to the buildup of oil-soluble acids, which can be corrosive, while oil-insoluble oxidation products will drop out, forming sludge and lacquers that impede oil flow and coat devices.

The word "uninhibited" in this context means only that there is no added synthetic antioxidant in the product, such as a hindered phenol or diphenylamine. It does not mean that there is no inherent antioxidation capacity. With Group I and naphthenic base stocks processed by solvent extraction, a portion of the residual sulfur species confers one form of inherent oxidational resistance.

There are two forms of inhibition, or antioxidant activity, in hydrocarbon preservation, namely primary and secondary. They are largely distinguished by how early in the overall oxidation process the antioxidant intervenes. Primary inhibitors intervene early and prevent some, but not all, oxidation products forming or propagating. Secondary antioxidants intervene later in the process and convert some of the otherwise highly unstable oxidation products, such as hydrocarbon peroxides, to more chemically stable and acceptable compounds, but still oxidized.

Ideally, base oils in formulations should have a mix of primary and secondary antioxidancy, but in cases where original equipment manufacturers (OEMs) forbid synthetic primary inhibitors, the formulator has to make best use of the natural or just secondary antioxidancy of base stocks together with the inherent oxidational resistance quality of hydrocarbon components comprising the base stock.

The aromatic extracts from Group I or naphthenic solvent extraction are highly concentrated in some sulfur-containing secondary antioxidant species. Such sulfur-containing molecules are associated with the other polar aromatic molecules, such as aromatics, that solvent extraction seeks to remove but never does completely. Previously, these process-derived distillate aromatic extracts were sometimes blended back into finished base oils to optimize antioxidancy performance. They were not regarded as synthetic or added antioxidants, being associated with crude feedstocks in the first place. This has ceased to be an option in most countries, with the health, safety and environmental constraints on the use of distillate aromatic extracts, even if the final levels of polyaromatic hydrocarbon are below the 3 percent mass levels required by the IP-346 test standard for carcinogens. So retention of original sulfur-containing species needs careful adjust-

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ments in the base stock processing straight-run if this is to be the source of an antioxidancy buffer.

Hydroprocessing has been the single greatest advance in base oil processing. However, it does leave base stocks essentially sulfur free and consequently without any significant natural secondary antioxidancy, or much scope for use as uninhibited base stocks. One reason why hydroprocessing never really widely caught on for Group I manufacture was because such base oils are sulfur free in a high aromatics environment, which is the worst possible combination, making them inherently oxidatively unstable in the supply chain prior to formulation.

Hydroprocessing and hydrofinishing through to Group II or Group III, with trace aromatics and inherent stability, becomes much less of an issue. But even with Group II and III, it is still almost impossible to achieve adequate service performance as uninhibited base stocks for applications such as heat transfer fluids or transformer oils.

Uninhibited electrical oils are particularly difficult to formulate, since some OEMs want neither sulfur containing species because of copper corrosion issues nor synthetic primary antioxidants for acute antioxidant exhaustion reasons.

The reason there is a resistance in some applications to use just primary synthetic antioxidants to inhibit low-sulfur base stocks is that upon exhaustion of that primary antioxidant, the oil can become acutely unstable, with safe performance lost over a very short time period, effectively without warning. This could be dangerous in heat transfer or electrical oil applications.

With naturally inhibited base stocks such as solvent-extracted Group I or naphthenics and exploiting the secondary antioxidant effect, we find a much more gradual deterioration of performance, giving a wider, safer window of time for an oil drain and replacement.

In the case of heat transfer fluids in high-temperature industrial applications, light, well-extracted Group I based products can still be the preferred option where there is a natural abundance of secondary antioxidant sulfur-containing molecules doing a perfectly acceptable job.

It is possible to use some uninhibited straight base stocks in moderate severity lubricant applications, such as circulating oils. These are generally applications such as in steel mills where relatively large bearings or low stress gear applications can be serviced with, for example, an uninhibited Group I-based oil.

Turnover of lubricant will be large due to water and other contaminations, so a simple uninhibited oil will often do the trick for the short service life required. Again, residual sulfur species provide limited oxidational and even some antiwear performance.

Of course the decline in Group I base stock volumes and limited cover from solvent extracted naphthenics availabilities will focus attention on whether truly uninhibited lubricant and process oil applications has long-term viability.

All base stocks – especially those made by extraction mechanisms – benefit from good feedstock selection. Both naphthenic and paraffinic base stocks can be given a head start by having hydrocarbon components that are most resistant to the initial oxidation step undergo hydrogen atom extraction. These factors are generally well understood by good base stock manufacturers and can be tested experimentally as well as modelled during feedstock approval processes. OEMs also realize this too and will often give approvals for uninhibited base stock usage based on specific crudes only. □

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