ADDITIVE TREN
Zapping SAPS, Cutting Costs & Tackling Toxins

TLT’s poll of top additive-company managers provides an insider’s look at the trends that will be driving emerging technologies in the next five years.

By Kathryn Carnes
Features Editor
In June TLT conducted an informal survey of executives with the industry’s leading lubricant additive companies to gain insight into their current activities and vexations. We also hoped to get some notion of how they expect to be affected by certain high-profile and extensive regulatory initiatives—particularly in the United States but in Europe as well.

In short, we wanted to hear straight from the horse’s mouth how additive technologies will continue to evolve in the next five years. We also were interested in hearing about the key drivers of that change.

For our informal poll, TLT e-mailed a survey instrument to 233 execs and garnered 39 usable returns for an 18% response rate. The types of additives and additive packages our respondents manufacture and market are shown in Figures 1 and 2 (see page 35). Unaccountably, the survey developer (who also happens to be your humble scribe) failed to include antioxidants among the choices of additive types. Assuming that antioxidants are manufactured about as often as antiwear or extreme-pressure agents, the percentage of manufacturers offering antioxidants has been estimated conservatively at 50% in Figure 1.

Very few of the respondents market automotive engine oil packages, with only 9% offering passenger car motor oil (PCMO) or heavy-duty diesel engine oil (HDEO). Instead, a high percentage of the respondents are focused on industrial applications. Only 32 of the 39 respondents reported marketing additive packages, with metalworking fluid packages proving most popular at 50%.

Now let’s take a look at what you’re waiting for—emerging trends in additive technology.

**Trend 1: Zapping SAPS in HDEO**

The first market question we asked our execs was, “During the next five years, in which area do you expect most of your additive product R&D expenditures to be focused?”
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This level of attention is understandable given the pace of engine oil specification changes and the pressure that has been put on specific additive chemistries. Phosphorus, for example, is under fire on both the PCMO and HDEO sides, and sulfur (on its own and as a component of ash) is being pushed out of diesel fuel and HDEO because of its negative effects on emissions.

Additive companies are currently hard at work on finding ways to meet U.S. PC-10 heavy-duty diesel engine oil specifications. The emissions requirements are driving the development of new low/no-sulfated ash/phosphorus/sulfur (SAPS) oils—the top trend in our survey. The emissions requirements are driving the development of new low/no-sulfated ash/phosphorus/sulfur (SAPS) oils—the top trend in our survey.

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topic on the minds of several survey respondents. Although engine technology itself has improved in this regard, such gains have been facilitated and extended by the development of engine oils with lower and more stable viscosity. Charles Dushman of RohMax Additives USA’s Horsham, Pa., office, notes that the viscosity index improvers his company makes can help formulators meet both efficiency and emissions goals. “As you improve efficiency, you are able to do a unit of work while consuming less fuel, which decreases emissions. From our perspective, carefully formulated high-viscosity index fluids using appropriate share-stable viscosity index improvers can improve efficiency and emissions at the same time, which, we think, is of significant value to the industry.”

Related to PC-10, the TLT survey elicited several optimistic responses to the open-ended question: “What ‘intractable’ lubrication problem do you think will be overcome by additive technology in the next 5 or 10 years?” Perhaps because there is a sense of urgency to do so, the development of low-/no-SAPS engine oils topped the list. Replacement of ZDDP was singled out for particular attention, although sulfur reduction and ashless chemistry also were mentioned.

“The potential reductions in the levels of sulfur, phosphorous, and ash—ZDDP—is one of the biggest changes I have seen in the lubricants business,” says STLE-member Bruce Calvert of Uniqema, headquartered in New Castle, Del. “I think we can solve that with additive chemistry, which will be a milestone for this industry.”

While there may be a sort of universal call for low-/no-SAPS HDEO, some respondents hinted that heavy-duty engine technologies will begin to vary enough between companies and between regional/national markets to render industry-wide specifications relatively insignificant.

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Some would argue that this is already the case. HDEO marketers typically qualify their products to both the API’s industry-wide licensing standards and stricter individual-OEM (Mack, Caterpillar, Cummins, etc.) specifications.

“From a technology viewpoint and in an effort to control heavy-duty diesel development costs, it eventually may make sense to have OEM-specific lubricant specifications as opposed to industry-wide specifications,” said John McChesney, global business manager-antioxidants for Albemarle. “Diesel engine technologies may diverge to a greater extent as sulfur levels are driven lower and as quantum leaps in fuel economy are sought. The oil industry and the downstream service sector are fairly well positioned to handle ‘OEM oils’ in the [heavy-duty diesel] market. On the passenger car side, engine technologies remain fundamentally similar; therefore, industry specifications most likely will remain for a long time.”

In addition, McChesney noted, passenger car oil changes are handled in a more diverse marketplace. “It is one thing for the car dealership to carry the branded oil but a far more difficult task for the independent oil change operator to carry numerous engine oils for each OEM,” he said.

Differences in engine oil additive development that do arise for passenger cars will likely be due to regional differences that have promoted different fuels, said Vince Livoti of Ciba Specialty Chemicals, headquartered in Basel, Switzerland, with U.S. headquarters in Tarrytown, N.Y. “Europe and the U.S. are headed down different paths over the next five years. Europe’s passenger car fleet comprises a much larger percentage (~40%) of diesel vehicles due to tax advantages consumers realize by owning these cars.

“Thus, European oil specifications are largely driven by reduction of sulfated ash. Conversely, since the U.S. passenger car fleet is predominantly gasoline powered (97%), U.S. engine oil standards are driven by reduction of phosphorus. Different additives and formulation techniques will be needed to help both sides of the Atlantic meet the needs of their respective fleets.”

Despite this seeming flood of change, lube formulators and additive companies have long complained that engine oil specification changes are (in a sense) implement-
ed too slowly. That is, stepwise implementation of standards and the resulting incremental changes in engine technologies create unnecessarily burdensome work for the additive manufacturers and lube marketers by necessitating continual stepwise reformulation of engine oils, with an associated high cost of additive R&D and testing during engine oil development and certification.

These costs have long nettled additive companies, which have little time to recoup their investments before the next set of incremental specs is issued. This, too, was reflected in our survey. Several respondents said their companies would prefer that automakers change specifications less often but that the changes called for in new specs be more substantive.

Not that anyone expects this, however. “We believe that changes in passenger car gasoline engines will be incremental,” said Mayur Shah, global technology manager for Lubrizol Corp., headquartered in Wickliffe, Ohio. “The changes in heavy-duty diesel engines also will be incremental. We understand the regulatory demands that force the OEMs to modify engine designs, which, in turn, drive the need for changes in lubricant requirements.

“Chemical restrictions (driven by the need to protect aftertreatment devices), coupled with increased lubricant performance requirements, have had an impact on lubricant technology, which plays an increasingly significant role in delivering performance and environmental value,” Shah adds. “However, recovering return on investments is becoming increasingly difficult, and as an industry we have not been able to extract the true value in the marketplace.”

**Trend 2: Cutting costs through bench testing**

If costs cannot be recouped by changing engine oils less frequently, then perhaps the nature of R&D or of testing itself should be changed, said several survey respondents. As for R&D cost reduction through such techniques as computer simulation, molecular engineering and similar approaches to formulation planning and testing, additive companies expressed hopeful caution. Most respondents indicated that additive R&D is being somewhat improved by these techniques, but more than 20% said they are not
Engine tests are thorough but time-consuming and expensive. Additive manufacturers we surveyed said they would like to replace some engine testing requirements with bench tests, which take less time and cost less.

helping at all (see Figure 3 on page 35). Very few of the respondents reported incorporating any of these types of tools in their own labs, and among those who did, 20% said the results were only so-so or even disappointing (see Figure 4 on page 35).

More often, respondents mentioned substituting appropriate bench tests for some engine/rig tests in HDEO and PCMO certification testing. There is precedent, some noted, specifically calling attention to the Ball Rust Test (ASTM D6557), an 18-hour bench test that in 2003 replaced the Sequence IID test (ASTM D5844) beginning with ILSAC GF-3/API SL to evaluate a lubricant's ability to prevent engine corrosion, particularly rust formation.

“In the early stages of the Ball Rust Test development, one of the key criteria for test acceptance involved properly ranking industry reference oils relative to the IID test,” said Albemarle’s Gatto. “This was a difficult task initially because additive chemistries in the reference fluids showed differing responses between the two tests. Our approach [at Ethyl Corp., which spun Albemarle off in 1994] was to gain an understanding of component response in the test. The use of designed experiments with model formulations helped pinpoint specific chemistry types that were both beneficial and detrimental in the test. Having this knowledge, we were able to redesign the test to more properly rank the reference oils.”

A similar scenario may be playing out for the Thermo-Oxidation Engine Oil Simulation Test (TEOST), which, Gatto points out, is part of the current GF-4 PCMO specifications.

“We believe this is a very useful test for research in that both deposit tendencies and oxidation characteristics of an engine oil can be studied,” Gatto said, offering some data presented at this spring’s STLE Annual Meeting in Las Vegas (see Figure 5 on page 35). “Correlation of TEOST results to field performance is still an area that requires more work, but its importance as a deposit test bench tool for research cannot be stressed enough.”

In this case, of course, the TEOST would not replace engine testing but would be used to screen candidates for formulation.
“We have just been through a period of extraordinary change driven by important measures to protect the environment. This has placed a tremendous burden on the auto and oil industries.”

**Trend 3: Tackling toxins, industriously**

Automotive applications are not the sole focus of environmental legislation. Industrial oils are also under scrutiny for their environmental effects and eco-toxicity. In addition, these fluids are subject to increasing regulatory pressure to improve their worker safety and health profiles. Thus, also ranking high in our responses (enough to constitute our third identified trend among respondents) were pressures stemming largely from environment, health and safety (EHS) concerns related to industrial fluids.

Some of the concerns are rather across-the-board, others tend to vary by region/nation, our survey respondents indicated. Figures 6 and 7 show that national and regional differences in EHS regulations and legislation during the next five years were judged to be “very important” or “important” drivers of distinct additive products by 63% of survey respondents. Conversely, only 43% said regional/national differences in industry specifications or technology status during the next five years were “very important” or “important.” National/regional differences in marketing and distribution were judged to be relatively unimportant, with only 8% of respondents calling them “very important” drivers of additive development.

Specifically mentioned were the long-standing expectation that large users and governments will call for chlorine to be removed from metalworking fluids, cleaners and the like and anticipated reductions or elimination of heavy metals such as lead, cadmium, molybdenum and mercury. Also mentioned by various respondents were such concerns as biocides/bacteria, amines/pH/corrosion inhibition and overall levels of additives in formulations/multifunctional additives.

Many of these concerns become intertwined as additives are developed. For instance, “Our metalworking fluid formulator customers have been asking for additives that render the metalworking fluid emulsion less susceptible to bacteria and fungus growth,” says STLE-member Brent Brennan, marketing manager for Degussa Goldschmidt Chemical Corp., headquartered in Basel, Switzerland.

“As regulations and end-user perceptions of biocides tighten, formulators are seeking alternatives that minimize the health/exposure risks associated with metalworking fluids, Brennan adds. “Like many suppliers, we do not market biocides, and we do not claim our products are effective at eliminating bacteria from a metalworking fluid sump. However, as a full-line supplier of performance additives in the metalworking fluid market, we are seeking ways to develop products that extend the life of the fluids in which they are formulated.”

One such chemical, dicyclohexylamine (DCHA), has received some attention in the literature for its biocidal properties. However, cautions consultant Wheeler Crawford of Canyon Creek Chemical Consulting...
in Houston, amine chemistries (especially secondary amines, which form carcinogenic N-nitrosamines) are under fire for their EHS profiles. One, diethanolamine (DEA) has been banned from metalworking fluids in some European countries and “is considered anathema here [in the U.S.], too,” Crawford notes. “There are problems in Japan, U.S., and Europe with MEA (monoethanolamine)-containing fluids, which are banned at some automotive plants.”

Amines are looked to principally for pH, pH control (buffering) and inhibition of ferrous metal corrosion, Crawford notes, adding that several substitute chemistries exist, although there might be some cost penalty for using them. Still, such substitutions may be required.

“Amines, collectively, are on some hit lists because of their high pKa, volatility and irritation potential,” Crawford said. “The amine issue can be emotional, but one must be careful not to throw the baby out with the bathwater. There are certain selection criteria that should be used in selecting an amine for a metalworking application. The first must be its environmental, health and safety profile, including such things as a proper balance between biostability and biodegradability, volatility, pKa, skin irritation, odor and metal-leaching characteristics. The second criterion is performance.”

In some cases, Crawford notes, reducing the level of a particular amine might necessitate increased use of biocide, corrosion inhibitor or pH buffering agents, even if the overall drive is to reduce additive treat rates in formulations.

The importance of EHS issues to additive makers’ businesses was reflected in our survey respondents’ answers to questions about how they expect the industry to be affected by various governmental programs on chemical toxicology and safety. Asked “How do you think legal liability issues related to REACH (Registration, Evaluation and Authorization of Chemicals), HPV (High Production Volume), Endocrine-Disrupter and similar programs will affect the number of additive companies during the next five years?” 70% of respondents said they expect that new, safer, better-functioning additive choices will result from these efforts—setting a trend that should prevail for many years to come.

Conclusions
SAPS in engine oils, cost controls and EHS issues loom large in additive makers’ minds at the moment. Nevertheless, the industry seems confident that none of these challenges is insurmountable. Perhaps because these additive manufacturers recently survived a very busy era of corporate restructuring and consolidation—with many of them bulking up in the process—they feel strong enough to tackle these tough issues. They also apparently expect that new, safer, better-functioning additive choices will result from these efforts—setting a trend that should prevail for many years to come.

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Solving lubrication’s ‘intractable’ problems
TLT asked our surveyed additive executives, “Which ‘intractable’ lubrication problems do you think will be overcome by additive technology in the next five years? 10 year?”

- Multifunctionality—creating multipurpose oils and lubricants.
- The development of high-performance ashless formulations.
- Nothing in the next five years. In the next 10 years we’ll have SAP-free additives.
- We will replace zinc dithiophosphate and come up with improved antioxidants to take products to greater temperatures.
- Robust, low-phosphorous and low-SAP engine oils.
- Cost pressures and declining markets will significantly reduce the amount and impact of industrial additive development. The only significant development will be in mandated areas.
- Longer change levels for all lubricants.
- Corrosion reduction.
- Better emission system compatibility.
- Solving the incompatibility of antwear systems with catalytic converter systems.