Fluids for New Generation Printing Technologies

Thomas M. Larson and Bruce M. Jarnot
Exxon Chemical Company and Exxon Chemical Americas
Baytown, Texas and Houston, Texas USA

Abstract

Synthetic isoparaffinic hydrocarbons have a 40+ year history as safe, high performance carrier fluids in liquid toners. A historical perspective of liquid photocopy is given as well as a review of liquid toner benefits. New technologies have introduced new performance requirements for carrier fluids, in addition to traditional fluid requirements. Hydrocarbon structures are reviewed as well as their relationship to addressing these new performance requirements. The health and environmental impact of using aliphatic hydrocarbons in non-impact printing applications is reviewed.

Introduction

Liquid toners have been an integral part of the development of electrostatic printing processes since their discovery in 1953 by Metcalfe and Wright.[1] Toners with isoparaffinic hydrocarbon carrier fluids were developed and commercialized in the 1960's and gained popularity as the toners of choice for black and white copiers. Liquid toners began to mature in the 1970's and technologies shifted to dry toner. Dry toner systems had comparable quality and the dry toner cartridges were more convenient to store. An evolution to liquid color technologies began in the 1980's due to a desire for higher resolution and improved translucency achieved by reducing the toner particle size. Giant advancements in computer power in the 1990's allowed imaging speeds that translated into on demand presses that compete with traditional offset lithography. Liquid toners offered the best vehicle for "offset quality" on demand prints at high speeds.

Synthetic isoparaffinic hydrocarbons have been used as carrier fluids in liquid toners since the inception of this technology. The molecular structure of a branched paraffin gives it physical properties that are ideally suited for an electrostatic toner. Isoparaffins are catalytically synthesized and completely hydrogenated, a manufacturing route that eliminates polar compounds and olefins. This lack of polars and olefins, impurities usually associated with crude oil derived hydrocarbons, minimizes reactivity with toner components and their environments. The lack of functional groups as well as the sterically hindered hydrocarbon structure prevent attack on plastic/metal parts and printable substrates. A branched paraffin is an insulator with very low conductivity and a low, consistent dielectric constant. The odor of a synthetic isoparaffin is very mild to virtually odorless. Its completely saturated structure provides good oxidation stability, resisting development of odor even after extended exposure to heat and other forms of energy. The branchiness of the molecule results in a very low density which corresponds to a lower heat of vaporization, requiring less energy for evaporation.

Current trends in new electrostatic digital printing technologies have prompted new requirements in addition to the traditional performance benefits. Requirements such as lower odor, lower emissions, low impact on the environment, low toxicity, high exposure limits and freedom from regulations must be addressed in today's marketplace. Expensive resourcing and development time have been spent in an effort to replace isoparaffins as carrier fluids. An alternative to complete redevelopment is to address these new requirements using an expanded state of paraffins, taking advantage of expanded physical properties and safety, health and environmental advantages.

Isoparaffins for New Particle Synthesis Technologies

In an effort to narrow particle size distribution and enhance the stability of liquid toners, toner particles can be synthesized in the actual carrier fluid.[2] Isoparaffins play a dual role as excellent polymerization diluents as well as proven carrier fluids. During polymerization, isoparaffins have sufficient solvency for the monomers, but have little or no solvency for the polymer - eliminating attack on the finished particle and providing lower solution viscosities. Isoparaffins are virtually free of polar and olefinic impurities that can reduce yields or "poison" the synthesis. Once polymerized, the concentrated toner can be diluted with any size isoparaffin - eliminating the need to drive off the polymerization medium or dry the toner particles. FDA Regulation 21 CFR 178.3650 permits the use of certain isoparaffins (300-650°F BP) in the manufacture of polyolefin articles for food contact.[3]

Lower Odor Through Lower Vapor Emissions

Figure 1 illustrates a fluids performance matrix that can be used to customize the physical properties of an isoparaffinic carrier fluid to meet formulation requirements. Historically, a 100°F flash point isoparaffinic product has been the industry standard. There is a wide range of similar isoparaffinic fluids available, primarily differing in molecular weights. The very mild odor associated with the industry standard can approach undetectable by replacing it with a heavier , higher MW isoparaffin. This reduces the vapor pressure of the fluid, reducing the molecules available in the workplace for odor detection. Heavier isoparaffins have been blended with mineral oils to reduce the vapor pressure to even lower levels. The inherent oxidative stability of the heavier isoparaffins in heat and light minimizes the formation of oxy compounds, impurities that increase odor and increase conductivity. Vapor emissions can be further reduced by the use of engineering controls, generally a condenser that converts the vapors back to a liquid for recycling. Increasing the MW of the carrier fluid also serves to reduce the condensation temperature, helping the efficiency of the condenser.

HIGHER MW <——————————————>LOWER MW
Lower Odor <——————————————> Higher Odor
Lower Vapor Emissions <—————> Higher Vapor Emissions
Lower Condensation Temp <——> Higher Condensation Temp
Non-Combustible <——————————————> Flammable
Slower Evaporation <————————> Faster Evaporation
Higher Surface Tension <—————> Lower Surface Tension
Higher Viscosity <——————————> Lower Viscosity

Figure 1. Effect of molecular weight on isoparaffinic fluid performance

Using the same strategy, the formulator can reduce the emissions of volatile organic compounds (VOCs) to an acceptable level while reducing hydrocarbon waste.

Low Surface Tension for Superior Spreadability

In an effort to reduce the amount of carrier fluid used while spreading the toner over a large surface area, the formulator requires a fluid with good flow properties. Isoparaffins inherently have low surface tensions, the force that attracts the molecules to each other. This property imparts superior spreadability and wetting. The spreadability is important when trying to minimize carrier fluid per unit area. The wetting helps the toner flow into microscopic surface imperfections on the substrate, improving adhesion. Increasing the MW of an isoparaffin increases the surface tension, but not dramatically.

Health and Environmental Issues

Beyond performance, synthetic isoparaffinic hydrocarbon fluids typically offer significant product safety, health, environmental, and regulatory advantages over both conventional petroleum distillates and dry powder toner formulations.

As stated earlier, synthetic manufacture of isoparaffinic fluids typically eliminates trace polar and olefinic impurities normally present in conventional petroleum crude oil distillates. The resulting high purity of these isoparaffinic hydrocarbons provides ultra-low odor characteristics needed in an office printing environment.

Synthetic isoparaffinic hydrocarbons are generally regarded as very safe toner components. From a health perspective, they typically have very low acute toxicity (often meeting FDA and USDA requirements for direct human food use), no eye, respiratory, or non-occluded skin irritantcy (often used in cosmetic and personal care formulations), no skin sensitization potential, no cumulative or developmental toxicity, no mutagenic or genotoxic activity, and very low inhalation potency. The high occupational exposure limits established for these hydrocarbon fluids further supports their workplace safety and low toxicity.

Fluid carriers also reduce potential exposure to toner powder, as pigments and other dry components are intimately incorporated into the carrier liquid matrix. The carrier fluid provides a significant barrier to potential health risks resulting from exposure to toner dust; in fact, health and regulatory classification of potentially hazardous dry toner components may be significantly reduced by being "inextricably bound" in a hydrocarbon fluid.

Due to their typically high compositional purity, synthetic isoparaffinic hydrocarbons may not be subject to certain US environmental and safety regulations. These fluids often do not contain HAPs or SARA 313 reportable components, and may not be regulated under CERCLA, RCRA, or California Proposition 65. In the environment, these fluids typically have very low aquatic and animal toxicity, and often meet the criteria for classification as "readily biodegradable". Isoparaffinic fluids typically used in non-impact printing have low volatile emissions, which combined with their low photochemical reactivity results in a negligible contribution to ozone or "smog" formation. The flammability of heavier synthetic isoparaffins used in new generation printing technologies typically ranges from combustible to non-regulated, with flash points from 144°F to over 200°F. These lower-flash point isoparaffinic hydrocarbons have favorable fire code ratings and relaxed regulations on use and storage.

Conclusion

Synthetic isoparaffinic hydrocarbons remain the top choice for toner carrier fluid applications, providing both optimal performance characteristics and significant product safety, health, environmental, and regulatory advantages. These same benefits make them excellent polymerization diluents for new particle synthesis techniques.

References

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Biographies

Tom Larson began his 18 year career at Exxon Chemical as an organometallic chemist developing metallocene catalysts in a long range polymers research team. After commercialization of the polymer catalysts, Tom began evaluating catalyst systems for hydrofining and hydrogenating hydrocarbon feedstocks to make specialty hydrocarbon fluids. He then provided technical support for the application of these hydrocarbon fluids in several end uses. In 1995 Tom was assigned worldwide market development responsibility for hydrocarbon fluids in non-impact printing and printing inks. He has a Bachelors of Science degree in Chemistry from the University of Iowa. Tom is a member of IS&T, NAPIM, and the American Chemical Society.

Bruce Jarnot received his Ph.D. in Biochemistry from Wesleyan University in 1986 and Board Certification in Toxicology in 1993. Following post docotral work at the University of Connecticut, he spent seven years in applied toxicology and product safety with the U.S. Air Force in Dayton, Ohio. Bruce joined Exxon Biomedical Sciences in 1994 where he supervised toxicology support for hydrocarbon and oxygenated fluid products. In 1997 he began an assignment with Exxon Chemical Company in Houston where he coordinates Product Stewardship and Health/Safety/Environmental and Regulatory support for hydrocarbon fluids.