

Crystallization of paraffin wax

Wax deoiling technology for the future

Today, most paraffin waxes are manufactured from crude oil. However, because of the low natural gas prices, the production of synthetic fuel based on gas-to-liquid technology is becoming increasingly important. Sulzer has developed a new crystallization process to refine high-quality paraffin from the by-products of synthetic fuel production.

Waxes have been used in many different ways since the early days of humankind. The most important application of waxes is for candles. Although no longer used for primary illumination, candles are currently the fastest growing segment of the wax market. Candles that burn well and do not soot are high-quality products. Candle producers make sourcing decisions based on the purity of the waxes. The Sulzer wax deoiling process has been established as the leading technology for the production of high-purity paraffin waxes. In addition to their use in candles,

In addition to being used in candles, wax is used for many other applications like cosmetics and rubber tires.



there are many other applications for high-purity waxes:

- Waxes are widely used in cosmetic products such as lipstick, mascara, moisturizing creams, and sun blocker. Fully refined wax is non-toxic and many products are approved for direct use in food and personal care formulations (source: American Fuel & Petrochemical Manufacturers AFPM).
- Wax is used to cover certain types of cheese that would dehydrate if not properly protected. It is sprayed on citrus and other types of fruit to protect the fruit from oxidation and enhance its appearance.
- Waxes are present in most hot-melt adhesive formulations, where they control the viscosity of the adhesive and contribute to open time, flexibility, and elongation.
- Wax is a vital component in rubber tire formulations. It is added for protection against atmospheric ozone that “dries” unprotected rubber, leading to cracking that compromises the strength of the tire. Wax creates a physical barrier between the tire surface and the atmosphere.

Established Sulzer deoiling process

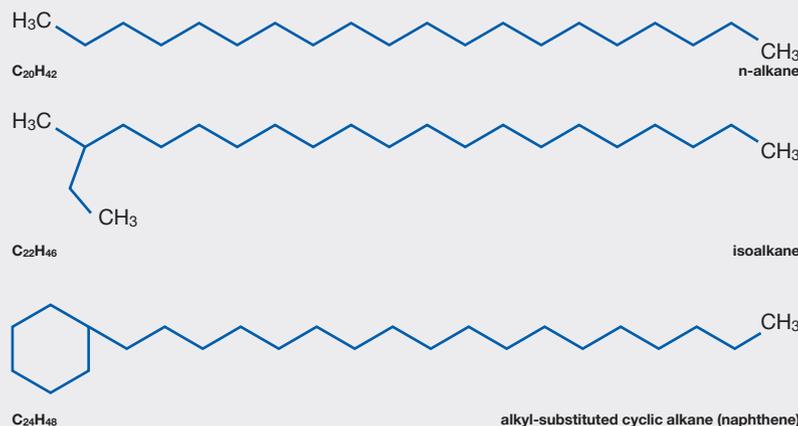
Crude oil is the most important source for paraffin waxes. Depending on the source of the crude oil, the content of solid waxes can vary between 3% and 15%. Waxes are part of the residues of the crude oil atmospheric distillation unit because of their higher boiling ranges. In processing the residues to lubricating oils, waxes are obtained in all fractions of the vacuum distillation unit. Waxes must be removed from the lubricating oil. They cause a high pour point of the oil because of their poor solubility. If the oil temperature is below the pour point, solid waxes will begin to precipitate. The flow characteristics of the oil will be adversely affected and oil filters will be blocked.

Slack waxes are produced through the dewaxing of lubricating oil distillates (see infobox). During the dewaxing, the paraffin waxes are separated from the lubricating oil by solvent extraction pro-

Structure and source of paraffin

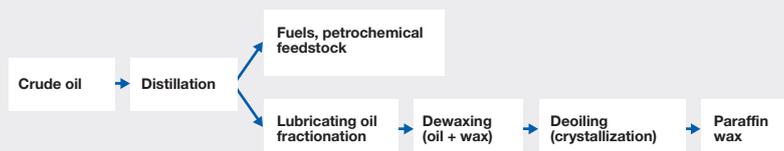
Paraffin is a complex composition of hydrocarbons. High-molecular-weight paraffin is solid at room temperature and has a wax-like consistency. Paraffin waxes consist mainly of mixtures of straight-chain alkanes. Their molar mass distribution depends on the boiling range of the lubricating oil distillate from which they are obtained. Long-chain, weakly branched isoparaffins are present in a lower proportion, along with a very small fraction of monocyclic paraffins.

Examples of paraffin wax structures

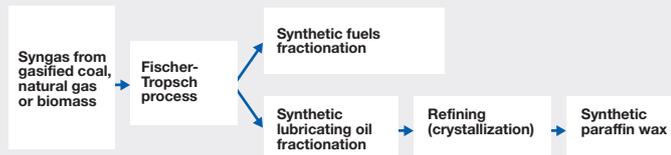


There are two processing routes in the oil and gas industry that deliver paraffin wax as a by-product:

1. Distillation of crude oil



2. Conversion of natural gas, gasified coal, and biomass to synthetic fuels



API base oil categories

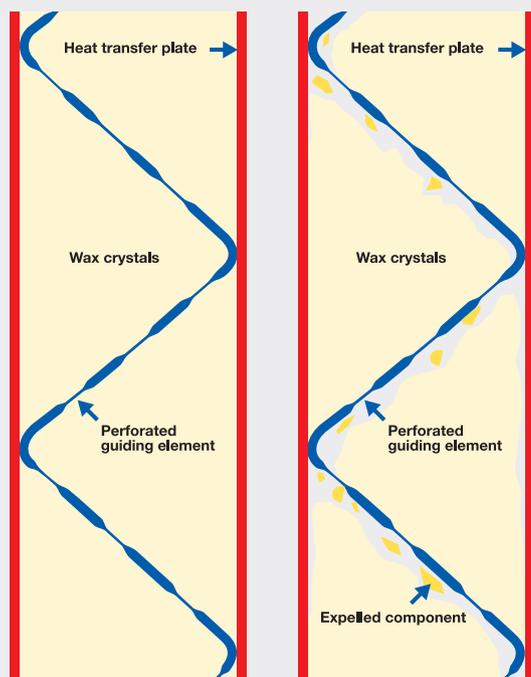
	Base oil category	Sulfur (%)	Saturates (%)	Viscosity index
Mineral	Group I (solvent refined)	>0.03 and/or	<90	80 to 120
	Group II (hydrotreated)	<0.03 and	>90	80 to 120
	Group III (hydrocracked)	<0.03 and	>90	>120
Synthetic	Group IV	Polyalphaolefin (PAO) synthetic lubricants		
	Group V	All other base oils not included in Groups I, II, III, or IV		

1 Base oil (lubricating oil) is categorized into five groups (Source: American Petroleum Institute). The production of Group I base oil, which delivers slack wax, is declining. The increasing production of Group II base oils delivers no slack wax. Therefore, paraffin from synthetic base oil is becoming increasingly important.

A new refining process for synthetic paraffin

Crystallization is one of the most powerful purification methods available in process engineering. Static crystallization is a process using vertical plates, which are heated or cooled by internal circulation of a heat transfer medium (HTM). The plates are suspended in the molten feed. Slow cooling of the HTM below the freezing point of the stagnant melt causes a layer of crystals to grow on the plates.

More information: www.sulzer.com/static-crystallization



Structure of the paraffin layer at the end of the crystallization process.

The paraffin layer during sweating (partial melting): The expelled components with high oil content are led off in a downward direction.

cesses. The paraffin-enriched by-products of these processes are a mixture of oil and wax, the so-called slack waxes. The Sulzer deoiling process is used to purify the slack waxes. It comprises a modern three-stage process with a static crystallizer that reduces the oil content to below 0.5%. Production of the first plant of this type worldwide commenced at Sasol Wax GmbH in Hamburg, Germany, in 1998.

The Sulzer deoiling process separates the majority of the hydrocarbons that are liquid and soft under normal conditions. These hydrocarbons are mainly low-molar-mass normal- and isoparaffins, as well as naphthenes and alkyl aromatics. In deoiled slack waxes, the normal and weakly branched isoparaffins are enriched. The deoiling process purifies the wax but also increases the hardness and congealing point of the paraffin wax, both important quality criteria.

Change of market

Today, the global annual demand for wax is about 4.4 million tons, whereby the most-produced wax types are recovered from crude oil. Of the total wax production, about 85% is from crude oil, the rest is synthetic wax. However, this

number will change very quickly due to the declining production of slack wax. Paraffin waxes are a by-product from the production of lubricating oils (base oils, see table 1), which form the major part of the motor oil used in cars. The so-called Group I base oils are produced by solvent refining, a simple and low-cost refining process, which is also the source for slack wax. In the meantime, the market demands more and more Group II base oils. These are manufactured by hydrocracking the paraffin components, leaving a better product at similar costs. However, no slack waxes become available from Group II base oil production.

Synthetic wax increases in significance.

Due to the declining availability of slack wax, synthetic wax from Fischer-Tropsch processes will become increasingly significant. Fischer-Tropsch waxes are by-products of liquid fuel production based on coal or natural gas (see infobox p. 13). Large investments are expected for this gas-to-liquid (GTL) technology driven by the US shale gas revolution and very low natural gas prices.

New process for synthetic paraffin

The Fischer-Tropsch process converts syngas, a mixture of carbon monoxide and hydrogen, into liquid hydrocarbons. This process forms the basis of the gas-to-liquid technology and produces synthetic lubricating oil and synthetic fuel, typically from coal, natural gas, or biomass. A wide range of different chain lengths produced is then used, mainly for the production of fuels and solvents, while the components with the highest boiling ranges are called Fischer-Tropsch waxes. Fischer-Tropsch waxes consist essentially of normal paraffins with chain lengths between 20 and 75 carbon atoms. The properties of synthetic paraffins are fully compatible with those of paraffin waxes from crude oil. In the past, synthetic waxes were mainly used for special applications such as hot melt adhesives, ink coatings, cosmetics, and coatings.

² Refined waxes will be used in the future for high-performance applications like precision castings for the fabrication of aircraft turbine blades. Sulzer applies this method for the manufacturing of replacement parts for industrial gas turbines: www.sulzer.com/gas-turbine-parts



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Fischer-Tropsch waxes can be used for the same applications as natural paraffin hard waxes. However, a further refining process is needed to attain the same properties that the paraffin waxes from fossil oil have. Sulzer has developed a new process for refining synthetic waxes that is based on the proven wax deoiling tech-

enables the manufacture of waxes with a desired hardness, oil content, and congealing point. In addition, the process is environmentally safe thanks to the closed nitrogen-blanketing system and the absence of solvents. Consequently, there is no need for solvent recovery or handling. With exception of pumps and

valves (standard and proven components), the Sulzer process has no moving parts.

The new process for synthetic waxes shows high reliability and low operation costs.

nology. The refined synthetic waxes fulfill the extremely stringent requirements of the candle industry regarding hardness, congealing point, and oil content. The key equipment in this new process is Sulzer's proprietary static crystallizer, which has special features to treat soft, waxy products.

Maintenance is thereby reduced to a minimum. Due to reliable microprocessor-based process control, human labor is minimized and is mainly focused on production monitoring. The process can be very easily stopped and restarted if it has been interrupted, without any loss of time or product.

Advantages of the crystallizer

The refining of synthetic waxes through static crystallization is a successful and robust process. The crystallizer is equipped with vertical cooling elements, which are immersed in liquid wax. The waxes crystallize on the cold surfaces of the elements (see infobox p.14). Guiding elements, which are inclined towards the cooling elements, support the solid wax layer. These elements provide the surface for an efficient mass transfer between the solid and the liquid phase. Exact temperature control is a decisive factor for crystal growth and thus for the separation. After the cooling phase, the mother liquor is removed, following which, the crystal layer is gently warmed up. During this so-called sweating step, low-melting wax components are separated from the hard wax. For this, the guiding element has a perforation through which the liquid fractions with low-melting components are drained off. Finally, the remaining crystal layer is melted to release the refined liquid wax as liquid.

The new process for synthetic waxes shows the same reliability and low operation costs known from other Sulzer crystallization applications. The very flexible concept of countercurrent staging, combined with predetermined and carefully controlled mass and energy balances,

High-performance applications

Paraffin waxes from fossil oil will still be used in the future, and wax producers will be left to modernize their plants. However, the focus will be more on waxes with specific features for high-value applications than on the production of paraffin for candles. One example is the development of a method for obtaining hard mass models for precision casting. These wax models are used in the fabrication of modern aircraft engines (Fig. 2).

Modern wax applications are part of the strategy of Polwax S.A., a company located in Jaslo, in southeastern Poland. Polwax is currently the largest producer and distributor of refined paraffin waxes in Poland and one of the largest in Europe. In December 2013, Polwax put a new Sulzer paraffin deoiling plant into operation (Fig. 3). It replaced production from two old crystallization units. The new crystallizer will produce paraffins with better performance. Plant construction took only six months. "After the privatization two years ago, Polwax has put into operation one of our biggest investments. This installation uses the latest Sulzer technology and provides a huge advance from what we had before", said Dominik Tomczyk, CEO of Polwax.



3 Sulzer installed a new paraffin deoiling plant at the Polish company Polwax.

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