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Market Analysis for Fischer-Tropsch Waxes

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This study was funded through USDA's Agriculture and Food Research Initiative Regional Coordinated Agricultural Project Grant Program. For downloadable copies, please visit the Department's web site at the Biobased Energy Analysis Group's web site at http://beag.ag.utk.edu or the Southeastern Partnership fort Integrated Biomass Supply System's website at http://www.se-ibss.org/

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Introduction

Waxes are organic substances that are solid at room temperature but become free-flowing liquids at slightly higher temperatures. While the main commercial source of wax is crude petroleum, mineral wax can also be produced from lignite, plants, animals, and insects. Overall synthetic wax consumption in North America in 2010 was estimated at 420 million pounds (AFPM 2013a). The fastest growing wax markets are for hydrogenated vegetable and natural palm waxes. Synthetic waxes mainly represented by Fischer-Tropsch (FT) and polyethylene (PE) waxes currently represent 11 percent of global wax supply (Zaworski, 2011).

Currently, the United States imports a significant share of the waxes supplied (65.3 percent). International trade has grown increasingly important in wax markets, with the United States being a major global market demander. Important import source countries include China and Canada (AFPM, 2013a).

During periods of high petroleum prices, such as those seen in the 2008 and 2011 (Figure 1), and with the methods used in refining oil producing less by-product waxes, other sources of waxes are becoming economically

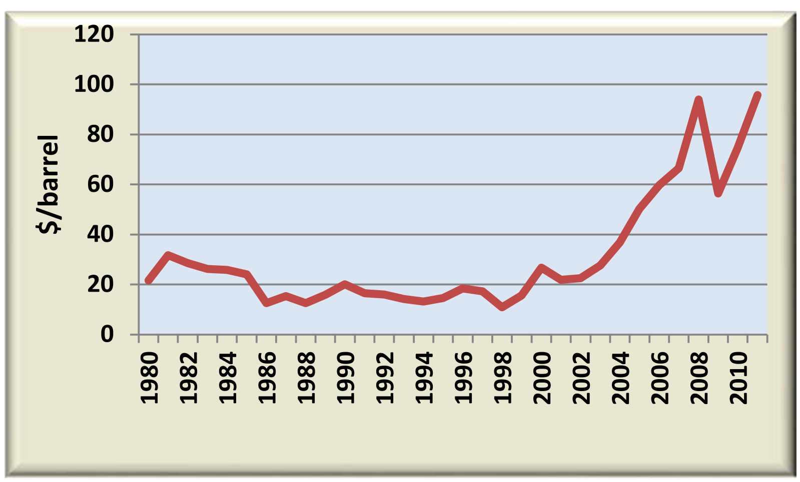

Figure 1. U.S. Crude Oil First Purchase Price, 1980-2011
(Source: DOE/EIA, 2013a)

more competitive. Examples of such a source are waxes produced as co-products in biofuels production. The purpose of this study is to examine potential markets for waxes produced with biofuels.

Fischer-Tropsch Process

Process Description

Gasification is one process pathway for producing biofuels. The process requires a high-temperature and a catalyst for biofuel production. The resulting product produced from gasification is a flammable gas called synthesis gas or syngas. Fixed bed, fluidized bed, and entrained flow are the three main reactor types used for gasification with each having advantages and disadvantages and corresponding operating temperature ranges. Before gasification can occur, some degree of biomass processing must occur. Normally size reduction and drying of the feedstock for gasification are required. Once the syngas is produced, contaminants (i.e., particulates, tars, alkali compounds, sulfur compounds, nitrogen compounds, etc.) must be removed or reduced so downstream processes are not affected. Once the syngas is cleaned, it is ready to be transformed into higher value products such as power generation, liquid-fuel synthesis, and chemical synthesis. Major commercial applications for the use of syngas include ammonia production from hydrogen, methanol synthesis, and hydrocarbons synthesis via the FT process. For FT catalytic synthesis, a variety of alkanes can be produced. Iron catalysts and high temperatures are used to produce gasoline-range products, whereas low temperatures and cobalt catalysts are used to produce diesel-range and wax products. As the temperature decreases, lower hydrocarbon chains form. Long-carbon-chain wax products are favored at low temperatures. If diesel products are selected, further hydrocracking is required in a separate unit adding capital costs for liquid fuel production (Swanson *et al.*, 2010). In order to produce waxes from FT catalytic synthesis, this gas-to-liquid (GTL) technology needs further commercial development.

Waxes produced via the FT process are considered synthetic waxes and may be classified as hard or medium. Because of increased pressure from governments, environmental organizations and the publics' pollution concerns, plus emissions from vehicles, GTL technology is expected to expand in the future. Another synthetic wax, polyethylene, and FT hard waxes are interchangeable to some degree. Medium waxes that have a high degree of inter-changeability include FT medium waxes, petroleum waxes, alpha-olefins, and natural waxes. Currently, shortages of hard waxes exist resulting in expected increased demand in the next decade from adhesives, inks, PVC lubrication, and new applications (Cook, 2010). Of the overall synthetic wax consumption in North America in 2010 of 420 million pounds, FT wax accounts for about 195 million pounds (AFPM, 2013a).

Commercialization

Sasol, a South African company involved in mining, energy, chemicals, and synfuels, uses proprietary FT technology to produce petrol and diesel from coal and natural gas. Solvents, co-monomers, ethylene, propylene, and FT waxes are extracted from the FT process. Sasol is currently involved in joint ventures or collaboration for projects located in Qatar, Iran, and Nigeria. The company is involved in a feasibility study for 80,000 barrels per day coal to liquid plant in China and is in planning stages for facilities to be located in Uzbekistan and North America (Sasol, 2013). Sasol Wax is expanding the Sasolburg hard wax production facility. The plant produces about 200,000t of hard waxes, medium waxes, liquid paraffins and waxy oils. The first phase will increase the capacity of the site by 40% (Chemicals-Technology, 2012).

South Africa's national oil company, PetroSA, has a GTL refinery at Mossel Bay producing 36,000 barrels per day. The refinery produces liquefied petroleum gas, petrol, diesel, and value added chemicals. Two main classes of chemicals are produced—alcohols and low-aromatic distillates. For the low-aromatic distillates produced, applications include inks and surface coatings, wax polishes, spray lubricants, among many others. Two new projects in the future include Project Ikhwezi, which will tap gas reserves in sustain GTL refinery in Mossel Bay, and Project Mthombo, which will be a crude refinery in the Eastern Cape (PetroSA, 2013).

Shell Middle Distillate Synthesis (Malaysia) located in Bintulu, Sarawak uses GTL technology to produce chemical feedstocks and waxes. The specialty waxes produced are used for hot melt adhesives, printing inks, cable filling, match sticks, corrugated board, fibre board, and PVC lubricants. With color additives, the waxes can be further used for crayons, candles, graphic arts and other decorative items (Shell, 2013).

Ras Laffan is an industrial city located near Doha, Qatar and is administered by Qatar Petroleum. The site utilizes technology for the production of liquefied natural gas and GTL products. Two synthetic fuel plants based in Ras Laffan are Oryx GTL and Pearl GTL. Both facilities convert liquid natural gas into liquid petroleum products. Oryx GTL produces 34,000 barrels per day of oil and was the world's first commercial-scale GTL plant (Quatar Petroleum, 2013). Pearl GTL is the world's largest GTL plant, producing 140,000 barrels per day of petroleum liquids (Pipeline and Gas Journal, 2011).

UPM, a Finnish pulp, paper and timber manufacturer, has three business groups that focus on energy and pulp, paper, and engineered materials. The fiber business, however, forms the foundation for UPM's strategy. More specific product groupings the company is involved in includes paper (both coated and uncoated), energy (emission free electricity and biomass based combined heat and power production), biofuels (biodiesel from gasification technology), pulp, forest services, timber, labels, plywood, composites, and biobased chemicals and additives (UPM, 2013).

Rentech, located in Commerce City, Colorado, and with partner ClearFuels employs biomass gasification technology to produce syngas for renewable power and fuels production. Using FT chemistry, the facility produces approximately 10 barrels per day of renewable and synthetic drop-in diesel and jet fuels. As part of their production process, the company produces specialty waxes and chemicals. Commercial-scale facilities are planned for White River, Ontario; Natchez, Mississippi; Rialto, California; and Port St. Joe, Florida (Rentech, 2013).

The Flambeau River Biofuels project in Park Falls, Wisconsin is projected to use 1,000 tons of woody biomass (wood) per day or 350,000 dry tons per year and produce 10 MMgy of FT waxes and 8 MMgy FT diesel or 9 MMgy of each (USDPE/EERE, 2013). This project is slated to be in operation by 2012 (Retka Schill, 2009).

U.S. Production and Supplies of Waxes

Product Supplied and Wax Capacities

Since the mid-1990's, U.S. product supplies of waxes have declined (Table 1). In 2011, the product supplied from the United States was 2,723,000 barrels, less than one-third of the 1996 peak of 8,789,000 barrels. A key factor in this decline of production of waxes is the changes in crude oil markets and refining. The production by refineries and blenders in the United States declined from a peak of 9,380,000 barrels to 3,038,000 barrels in 2011.

Table 1. U.S. Supply and Disposition of Waxes, 1981-2011

Decade	0	1	2	3	4	5	6	7	8	9
					Year					
					Product Supplied (Thousand Barrels)[a]					
1980s		6,581	5,146	5,595	5,541	5,670	5,525	5,911	6,131	6,043
1990s	6,014	6,344	6,729	7,229	7,330	7,331	8,789	7,900	7,652	6,761
2000s	5,975	6,563	5,810	5,606	5,555	5,665	4,722	3,953	3,457	2,207
2010s	3,085	2,723								
					U.S. Refinery and Blender Net Production of Waxes (1,000 Barrels)					
1980s		6,943	5,135	5,535	5,388	5,506	5,613	5,879	6,166	6,223
1990s	6,193	6,681	6,738	7,328	7,637	7,713	9,380	8,372	8,355	7,075
2000s	6,478	6,523	6,322	5,739	5,530	5,808	5,387	4,504	3,647	2,804
2010s	3,028	3,038								
					U.S. Imports of Waxes (Thousand Barrels)					
1980s		260	379	334	490	514	582	543	631	638
1990s	418	491	580	646	575	472	468	441	613	971
2000s	860	918	1,017	1,157	1,470	1,471	1,113	1,242	1,568	1,497
2010s	1,987	1,779								
					U.S. Exports of Waxes (Thousand Barrels)					
1980s		494	252	283	462	370	468	562	625	620
1990s	642	767	806	711	808	925	1,002	993	1,157	1,301
2000s	1,293	1,313	1,245	1,459	1,532	1,705	1,757	1,829	1,857	2,165
2010s	1,841	2,011								

[a]A gallon of microcrystalline wax weighs about 7 pounds (GlobalWax, 2013).
(Source: DOE/EIA, 2013b)

Figure 2 illustrates the downward trend in refinery and blender production from the United States, along with increasing importance of trade, both imports and exports. The location of much of the lubricating oil and wax capacity is in oil refining areas. Major lubricating oil and wax capacities from refineries can be found in Texas, Louisiana, Oklahoma, and California (Table 2).

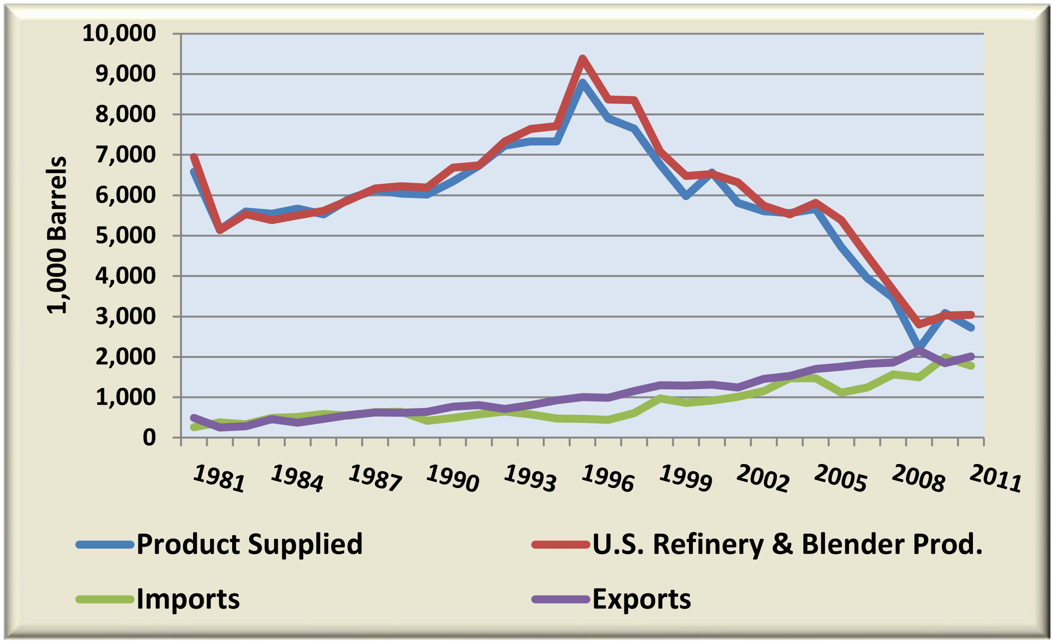

Figure 2. Supply & Disposition of Waxes in the United States, 1981-2011
Source: DOE/EIA, 2013c

Table 2. Lubricating Oil and Wax Capacities

U.S. Refiners	Location	Plant Capacity[a]
		1,000 barrels/day
American Refining Group	Bradford, Pennsylvania	3.6
Calumet Lubricants Comp	Princeton, Louisiana	9.7
Calumet Lubricants Comp	Shreveport, Louisiana	65.0
Chevron Corporation	Richmond, California	57.6
Cross Oil & Refining Comp	Smackover, Arkansas	7.0
Ergon Refining	Vicksburg, Mississippi	22.0
Ergon – West Virginia	Newell, West Virginia	6.0
Excel Paralubes[b]	Westlake, Louisiana	32.2
Exxon Mobil Corporation	Baton Rouge, Louisiana	182.9
Exxon Mobil Corporation	Baytown, Texas	282.0
Exxon Mobil Corporation	Beaumont, Texas	126.0
HollyFrontier Corporation[c]	Tulsa, Oklahoma	155.3
The International Group	Smethport, Pennsylvania	3.5
LyondellBasell Industries	Houston, Texas	280.4
Motiva Enterprises LLC	Port Arthur, Texas	64.0
Paulsboro Refining LLC	Paulsboro, New Jersey	160.0
San Joaquin Refining Comp	Bakersfield, California	14.3
Valero Energy Corporation	Three Rivers, Texas	3.2
	Total:	1,474.7

[a]Per EIA 2011 Petroleum Supply Annual
[b]Flint Hills – ConocoPhillips' Westlake
[c]Plant capacity data for both Tulsa East & Tulsa West
(Source: AFPM, 2013b)

The Fischer-Tropsch portion of the market is still relatively small accounting for about 1.45 percent of the U.S. market (Table 3). The Fischer-Tropsch wax supply would fall into the range of waxes with performance similar to modified vegetable wax.

Table 3. U.S. Wax Market Size

Product	Market Size
	MM lbs
Low Melt Paraffin	1,000
Mid Melt Paraffin	600
High Melt Paraffin	380
Polyethylene	275
Microcrystalline Waxes	220
Petrolatum	210
Fischer-Tropsch	40
Carnauba	12
Montan	10
Lanolin	9
Beeswax	7
Candelilla	1

(Source: Craig, 2007)

Wax Imports

Total Imports

Imports of waxes have increased steadily over the past several years (Table 4). Growth in wax imports has been driven by changes in U.S. production, plus a continuing growth in demand.

Import Sources

Canada's importance as a source of waxes has dropped dramatically, whereas China's importance has increased (Table 4). By 2011 (Figure 3), China held 43 percent share of U.S. wax imports on a volume basis. In 2011, wax imports to the United States totaled close to 1.8 million barrels. The top five countries exporting wax to the United States were China (769,000 barrels), Canada (257,000), Japan (150,000), Greece (140,000), and the United Kingdom

(85,000). For 2011, wax imports from these five countries totaled 1.4 million barrels, or 78.8 percent of total United States wax imports. Wax imports from South Africa (84,000) and Malaysia (75,000) combined totaled 159,000 barrels.

Table 4. U.S. Import Sources of Waxes, 2004-2011								
				Year				
Source	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
				(1,000 Barrels)				
Argentina							1	1
Brazil			27	6	6	3	30	
Canada	784	773	78	110	138	148	393	257
China	469	415	475	534	976	814	894	769
Taiwan			34	13	19		25	25
Egypt				23		22	66	38
France		4	4	75	4	16		
Germany		17	16	30	12	2	11	10
Greece						60	103	140
Hong Kong								23
Hungary	6	4	7	5	8	14	6	7
India				15				
Indonesia							2	
Israel								2
Italy			20	8		1		15
Japan	15	15	130	144	112	208	214	150
Korea				2			2	
Malaysia		142	219	163	149	125	132	75
Mexico	25	10	6	3				
Netherlands				5	3	2	1	2
Norway								16
Russia							1	2
Singapore	11			5				23
S. Africa	83	91	81	95	95	77	73	84
Spain			16	2				
Thailand	68					5	33	55
U.K.				4				85
Total	***1,470***	***1,471***	***1,113***	***1,242***	***1,568***	***1,497***	***1,987***	***1,779***

(Source: DOE/EIA, 2013d)

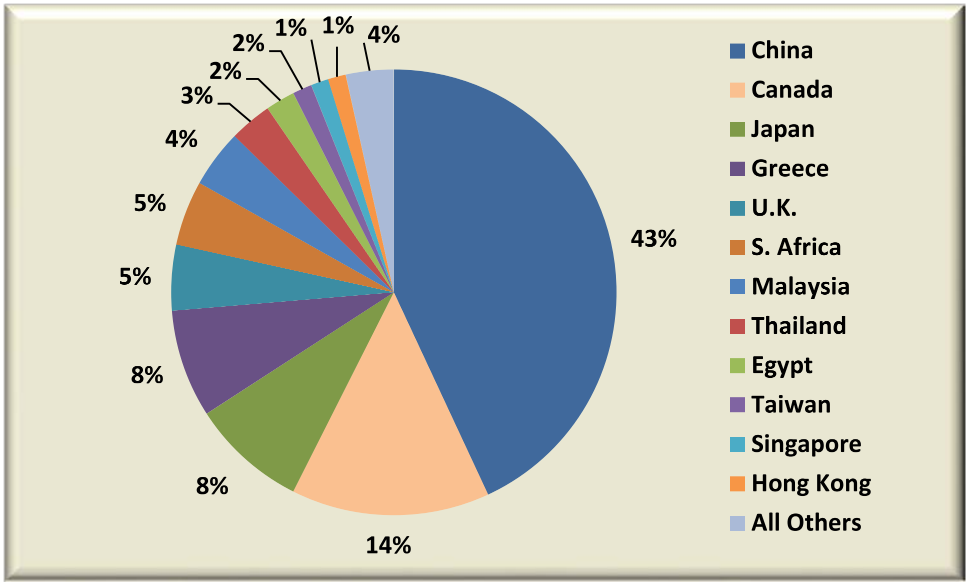

Figure 3. Shares of U.S. Wax Imports by Source, 2011
Source: DOE/EIA, 2013f

Asia is a key supplying region due to the combination of China's petroleum waxes, FT waxes from Malaysia, natural palm waxes from Malaysia and Indonesia, and PE waxes from Japan, Korea, and Thailand (Agashe, 2006). The top five U.S. ports receiving wax shipments were Philadelphia, Pennsylvania (648,000 barrels); Oakland, California (279,000); Buffalo-Niagara Falls, New York (241,000); New York, New York (132,000); and Richmond, California (123,000). In 2011, these ports received approximately 80.0 percent of the total wax imported to the United States. Wax imports from Malaysia entered the United States through Texas ports primarily, whereas South African wax imports entered California, New York, South Carolina, and Texas ports (USDOE/EIA, 2013e). Declines in paraffin wax supplies from North America (due to changes in Group I base oil production) and Western Europe have been offset by growing supplies from China (Zaworski, 2011).

Wax Imports by Type

The United States imports about 62 percent from paraffin type waxes, and about 38 percent microcrystalline and other waxes (Figure 4). During the past several years, the role of paraffin imports has increased relative to other wax types.

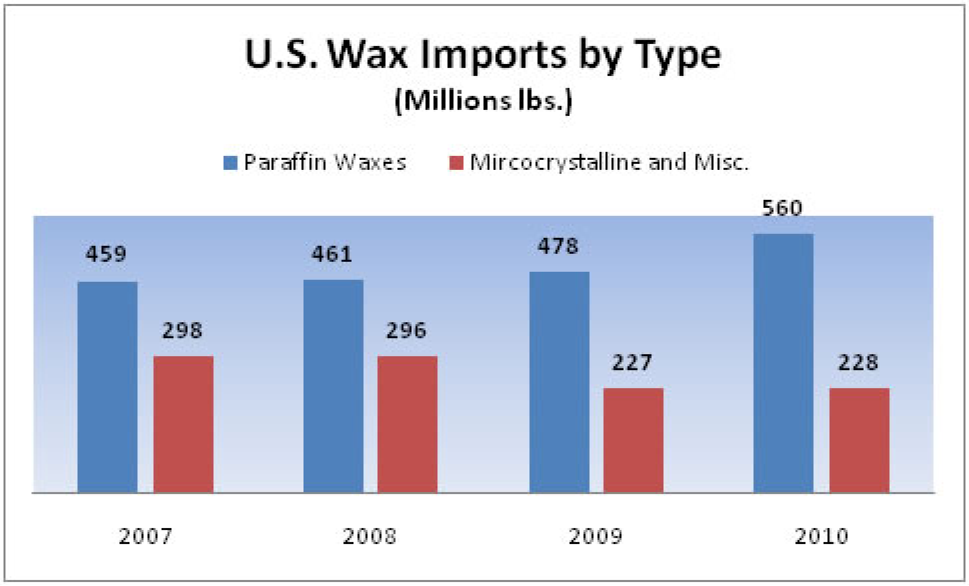

Figure 4. Wax Imports by Type into the United States, 2007-2010
Source: AFPM, 2013

Wax Exports

Total Exports

As can be seen in Table 5, overall exports of waxes from the U.S. have been increasing. Growth in wax imports by Canada has helped increased overall exports.

Export Destinations

Exports to Canada have increased from 870,000 barrels in 2004 to 1,162,000 barrels in 2011 (Table 5). Exports to Mexico, another key trading partner, have remained fairly level. While holding a much smaller share, exports to Belgium grew rapidly between 2004 and 2011.

Table 5. U.S. Export Destinations for Waxes, 2004-2011								
	Year							
Source	2004	2005	2006	2007	2008	2009	2010	2011
	(1,000 Barrels)							
Belgium	11	9	13	29	16	27	19	19
Canada	870	919	969	771	810	832	955	1,162
Chile	3	5	4	4	2	29	36	35
China	10	7	19	55	68	263	79	43
France	21	7	78	327	243	88	20	23
India	4	9	9	11	17	166	59	40
Japan	20	17	5	6	6	10	20	22
Mexico	471	595	549	516	555	422	476	462
Netherlands	2	1	6	10	26	84	43	102
United Kingdom	5	5	5	6	7	89	5	22
Total	***1,532***	***1,705***	***1,757***	***1,829***	***1,857***	***2,165***	***1,841***	***2,011***

Source: (DOE/EIA, 2013f)

In 2011, Canada imported about 58 percent of the wax exported by the United States (Figure 5). This was followed by Mexico, which imported 23 percent of U.S. exports. Much smaller proportions of exports go to a variety of countries in Europe, South America, and Asia.

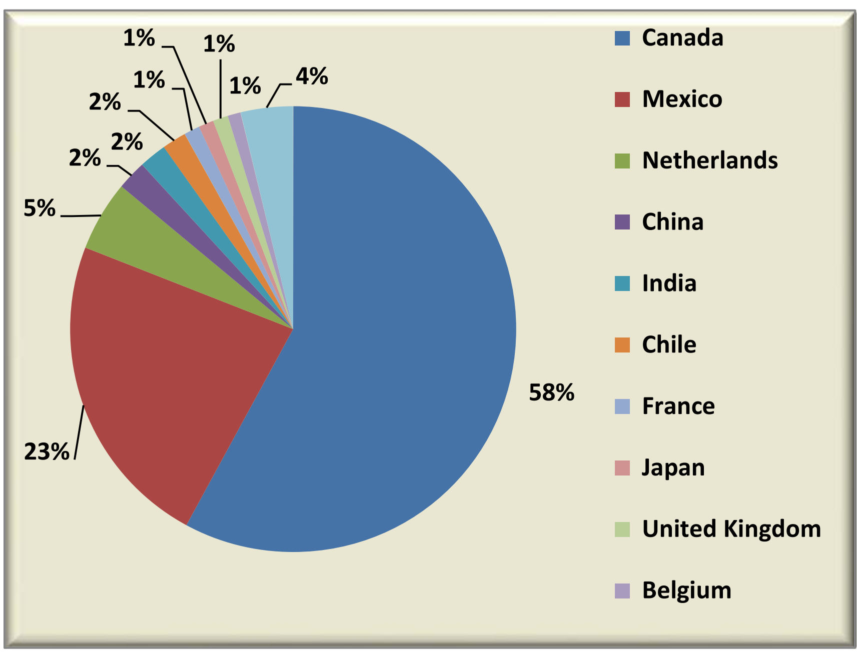

Figure 5. Shares of U.S. Wax Imports by Destination, 2011
Source: DOE/EIA, 2013g

Wax Demands

Wax consumption has been projected to grow at an average annual rate of greater than 2 percent from 2010 to 2020 (Craig, 2007; Zaworski, 2011). Waxes are used in a variety of products, including packaging, coatings, personal care products, and, of course, candles. Waxes can also be further processed into synthetic lubricants. FT hard and medium waxes have a variety of uses. Currently, shortages of hard waxes exist resulting in increased demand in the next decade from adhesives, inks, PVC lubrication, and new applications. Medium waxes can be used for making candles, while paraffins can used in polymers, bitumen modifiers, hot melt adhesives, and printing inks. Medium waxes can also be used in construction, packaging, paper, personal care, and tire industries. The largest volume growth in wax demand will arise from applications that currently use petroleum waxes (Cook, 2010). However, in order for FT waxes to play a role in meeting this demand, gas to liquid technology is needed (Cook, 2010).

Overall wax demands are largest for board sizing and candles (Figure 6). Combined these two products account for about 44 percent of the demand. These uses are followed by Rheology/Surface Application, which is in turn driven by plastics, tire, rubber and hot melt adhesives industry growth. The next largest category is corrugated boxes.

Petroleum wax production is driven oil industry developments, with production from this source expected to decline in the future (Figure 7). If a decline in production occurs, an undersupply will develop over next decade, with FT medium waxes being a candidate source to help meet this short fall. FT medium waxes have a high degree of purity (no sulphur, aromatics) (Cook, 2010).

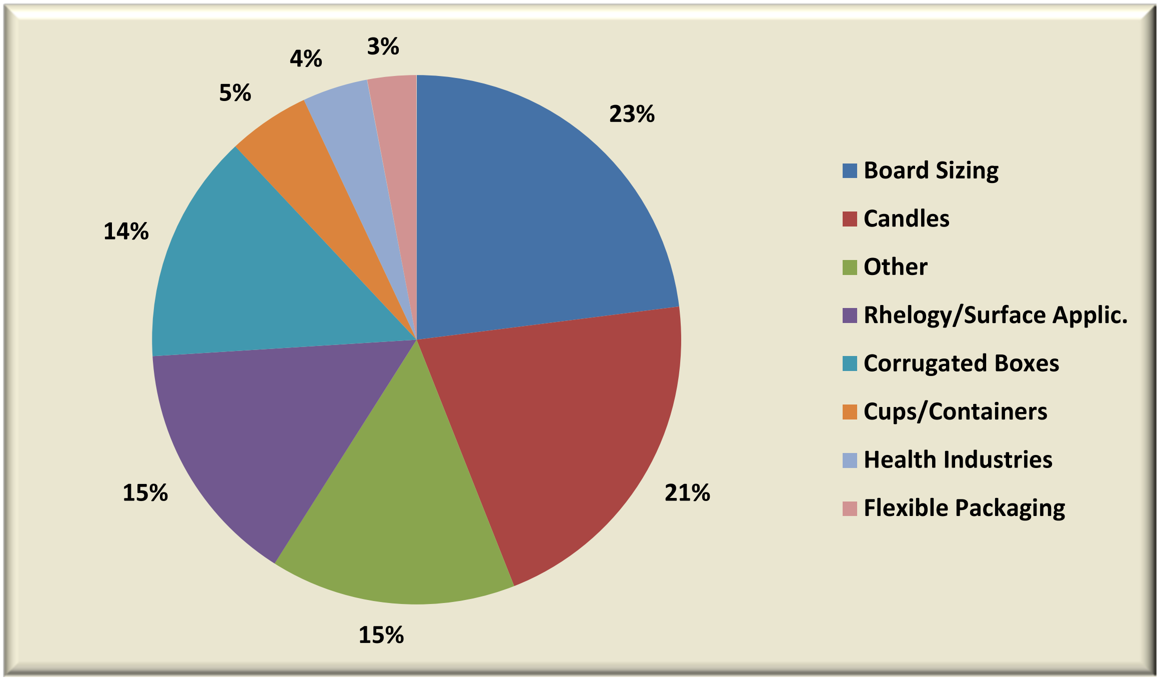

Figure 6. North American Wax Demand by Application, 2006
Source: Craig, 2007

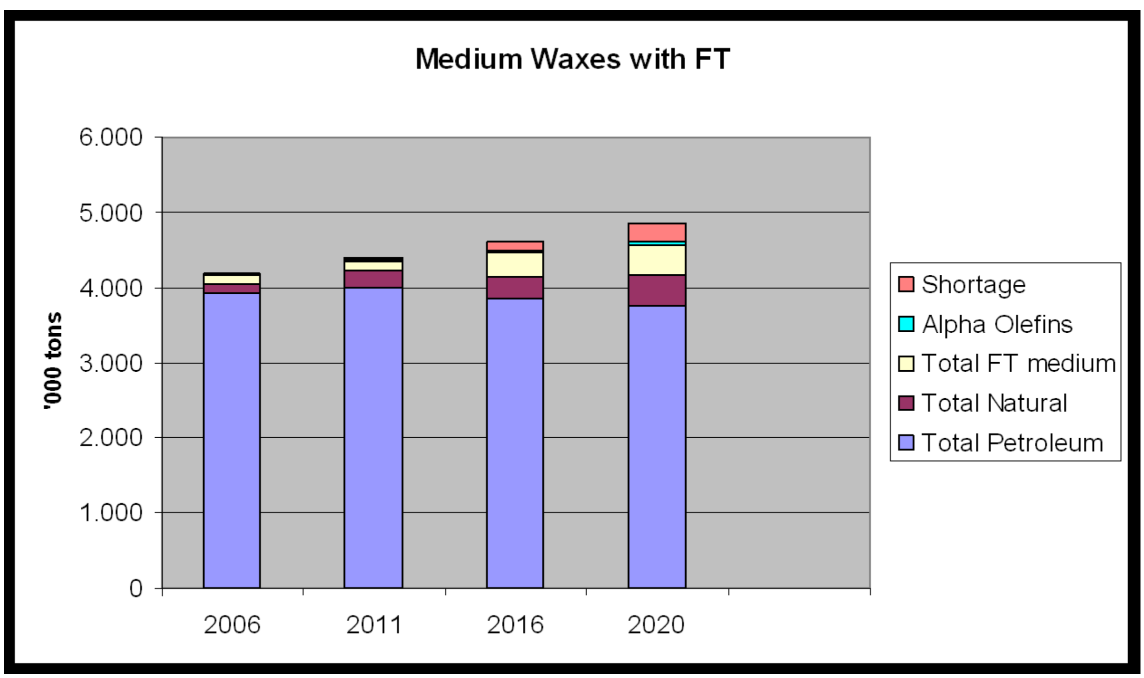

Figure 7. Production of Medium Waxes, 2006-2020
(Source: Cook, 2010)

The historical value of shipments from industries potentially using FT waxes are shown in Table 6. These wax using industries include candles, paint and coating manufacturing, resins, plastics, and synthetic rubber manufacturing, tire manufacturing, polish and other sanitation goods, corrugated and solid fiber boxes, and printing ink manufacturing. By far, the largest industries are resins, plastics, and synthetic rubber manufacturing.

Among industries potentially using FT waxes, several experienced growth in the 2000's until 2008/2009, with several of these industries experiencing a downturn (Figure 8). Several of the industries did gain value in 2010 however.

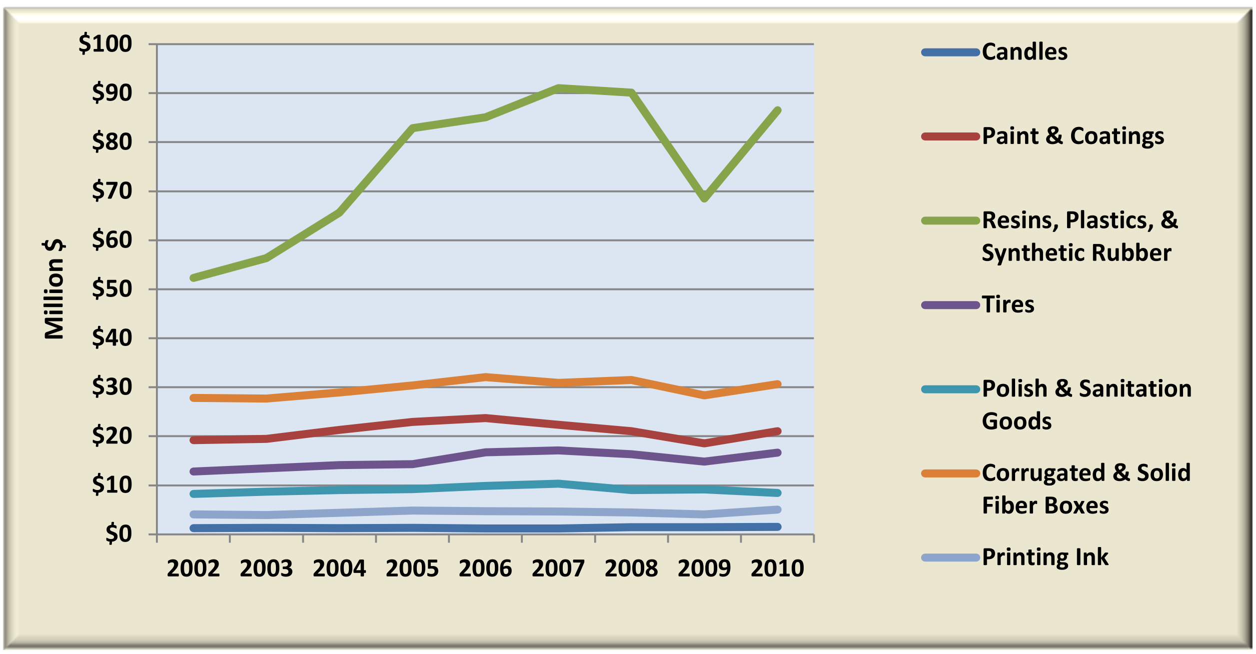

Figure 8. Value of Shipments by Industries Using FT Waxes
Source: Census Bureau, 2010

Table 6. Value of Manufacturing Shipments for Industries Potentially Using FT Waxes

NAICS	Description	2002	2003	2004	2005	2006	2007	2008	2009	2010
		Product Shipment Value ($1,000)								
339999	Candles	1,266,915	1,343,069	1,231,114	1,312,309	1,205,116	1,201,385	1,416,698	1,440,454	1,495,818
325510	Paint and coating manufacturing	19,235,657	19,499,529	21,305, 421	22, 906, 857	23,727,641	22,367,758	21,057,613	18,523,431	21,042,836
32521	Resin, plastics, and synthetic rubber manufacturing	52,321,610	56,366,464	65,655,975	82,858,829	85,114,327	91,011,605	90,129,994	66,850,1895	86,502,608
32621	Tire Manufacturing	12,789,156	13,470,727	14, 099, 140	14, 329, 174	16,748,256	17,115,613	16,321,926	14,840,563	16,630,467
325612	Polish and other sanitation good manufacturing	8,228,102	8,665,906	9, 001, 179	9, 224, 478	9,874,762	10,304,962	8,997,874	9,162,032	8,459,173
322211	Corrugated and solid fiber boxes	27, 851 ,507	27 ,686 ,609	28, 934, 796	30 ,363, 391	32,080,947	30,871,505	31,451,896	28,330,685	30,663,604
325910	Printing ink manufacturing	4, 044, 871	3, 940, 047	4, 395, 293	4, 833, 152	4,716,554	4,620,458	4,461,546	4,085,365	5,064,601

(Source: Census Bureau, 2010)

Wax Prices

Wax prices in the United States track Asian prices (see Figures 9 and 10). Both of these sets of prices are heavily influenced by petroleum prices (see Figure 1). In 2012, U.S. Bulk Slackwax (a semi-refined wax) prices were about $1,300 per MT. Prices for paraffin wax FOB at the US Gulf have shown a steady increase over the past several years (Figure 9). These increases were spurred by tight wax supplies and rising crude oil prices (Zaworski, 2011). Prices spiked in 2008 with the increase in crude oil prices. In 2012, prices averaged about $1,300 per metric ton. Asian paraffin prices were about $1,450 per MT. High melting point and low viscosity FT wax can bring as much as $2,500 per ton.

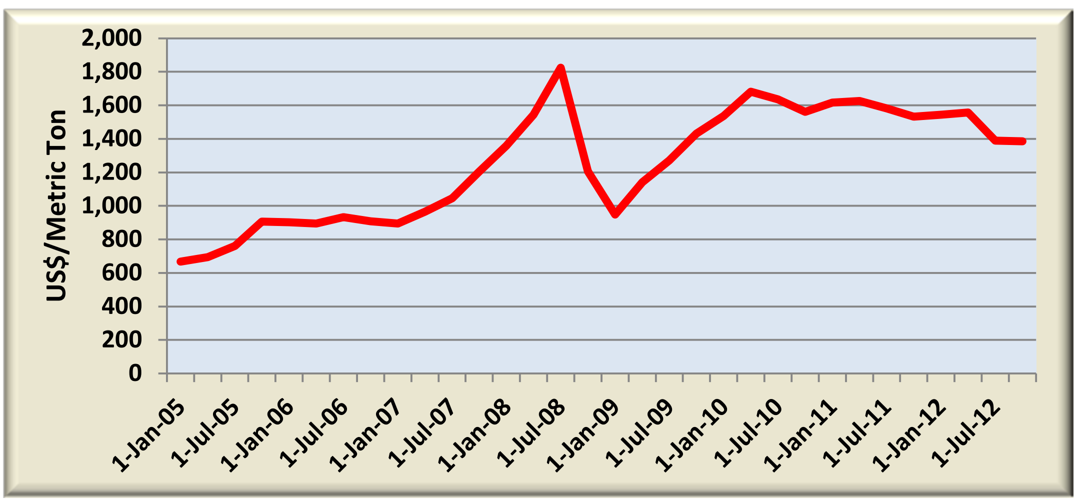

Figure 9. Paraffin Wax: FOB USG in US Gulf Spot Slackwax Bulk
Source: ICIS, 2012

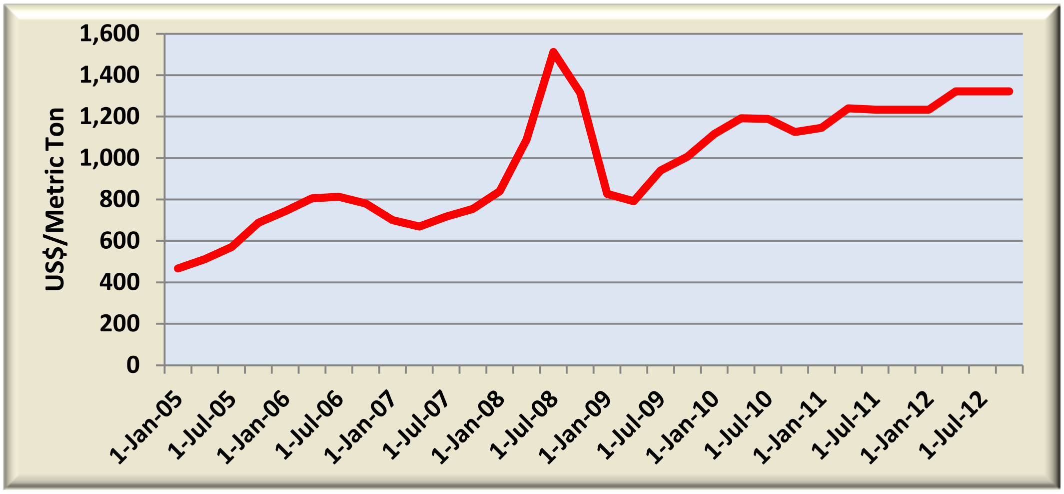

Figure 10. Paraffin Wax: CFR S.E. Asia Mp 58/60c In Asia Pacific Spot Fully Ref Slab

(Source: ICIS, 2012**)**

Conclusions

The desire to produce biofuels to help offset the United States reliance on imported oil will potentially drive growth in the biofuels industry. The Fischer-Tropsch technology can convert a variety of feedstocks, including biomass, wastes, natural gas, coal, or pet coke into transportation fuels. A co-product of this process is FT waxes. The market for FT waxes appears to be growing, as market demands expand here in the United States and overseas. The market has several suppliers in existence already; however, the majority of these are overseas. Traditional users of petroleum based waxes can constitute potential users of FT waxes. The plastics/resins industries, which are potential users of FT waxes overall, are continuing to expand in the United States, with a dip during the 2008/2009 period. In addition to domestic use, export markets, such as Canada and Mexico, for waxes may constitute another set of markets for FT waxes.

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