Soy Wax: An Alternative Resist

Dorothy Bunny Bowen

Prepared for the Kuala Lumpur International Batik Convention

December 2005

http://www.db-bowen.com/soywax/soywax.htm

Abstract:

For centuries the preferred waxes used in batik have been beeswax, vegetable and animal waxes, and more recently paraffin. While these mixtures can be boiled out of cotton, removal from acid-dyed silk requires dry cleaning, specifically the use of perchloroethylene, *a toxic chemical which is heavily regulated by the EPA in the USA. In the likely event that* perc *will be banned in the future, batik artists will either need to find another way to remove wax from silk or find an alternative resist.*

Bowen has been working with soy wax as an alternative resist on silk since 2002. Advantages are that the fumes are not toxic, melting point is lower, and the wax can be washed out with warm water and synthrapol. While soy wax shows promise as an alternative resist it is not generally recommended for immersion dyeing. The research will explore instances where artists can use soy wax for its unique qualities and thereby eliminate exposure to paraffin fumes and perc.

Introduction:

When I first began learning batik in 1980, our dry cleaner in New Mexico was happy to remove wax and charged by the pound. I never tried to remove any wax myself, just delivered it to him and a week later, picked it up with all the wax completely gone.

However, over the past few years, environmental regulations have tightened and my dry cleaner expects me to deliver the fabric with much of the wax ironed out, or steamed out, or both. Most of the time he doesn't get all of the wax out the first time, so it requires several trips (each a 50 mile round trip). Although wax resist on silk is my preferred medium as an artist, I expect that soon I will not be able to work in this way as the dry cleaning industry moves away from the use of *perchloroethylene*.[1]

In 2002, while doing a search on the internet for wax suppliers, I learned about a new form of wax which was developed in the USA for candle makers: **soy wax.** It melts at a low temperature and the fumes are not considered toxic *(see MSDS, appendix)*. Better yet, it was supposed to be removable by washing in warm soapy water. I ordered ten pounds of a pillar wax formula, and began experimenting with it.

Properties of soy wax:

Soy wax was developed in the early 1990's by Michael Richards, owner of a candle making company in Iowa. In 2001 Richards sold the patent for soy wax to Cargill, which now produces it.[2] Soy wax is a hydrogenated form of soy oil[3] which is used in the cosmetics, candle making, and paper coating industries.[4] Since it was originally developed for candles, specific formulas have been developed for different candle applications. *Container wax* generally melts at a very low temperature (c. 49–54°C, 120–130°F) and does not work well for the batik process. *Pillar wax* melts at a slightly higher temperature (c. 54–66°C, 130–150°F) and can actually be made to crack in a cool room, producing an interesting crackle effect. Different suppliers may sell formulas with additives to modify the wax properties, so it is advisable to ask questions when deciding which formula to purchase. One pound (.45 kg) of soy wax by weight will equal approximately 18 oz (.51 kg) of liquid when melted.[5]

Cost:

Soy wax prices are comparable to paraffin, though shipping costs may be considerable depending upon location. Since much of the world's soybean production is in the United States, so too are most of the wholesale suppliers *(see Appendix 3 for list)*.

Appearance:

Some pillar formula soy wax is sold in slab form and looks and smells much like white chocolate. It can be broken into smaller chunks much like paraffin, and stored in odd-sized boxes. My most recent order arrived as flattened opaque white .7 cm pellets *(pastilles)* in a 50 pound (22.7 kg) bag. This form is easy to measure by volume and can be stored in containers of any convenient size. Either form works, but I prefer the pellets for ease in handling and storage. *(Fig. 1)*

Melting process:

It is best to dedicate one wax pot to soy wax unless one plans to mix it with other waxes. As with all wax, it should never be heated to the smoking point. It should merely be hot enough to penetrate the fabric. This ideal temperature depends, of course, on room temperature and humidity.

Application of soy wax to fabric:

Soy wax can be applied with the *tjanting,* natural fiber brushes, metal stamps, *caps,* rollers, or any other tool which works for paraffin or beeswax. I keep separate sets of tools for soy and for paraffin/beeswax to avoid contaminating the soy wax, thereby requiring dry cleaning to remove wax residue.

Preferred fabrics:

Because soy wax is water soluble, it tends to break down when used on heavier fabric. Since the dyed fabric then takes longer to dry, the edges of the design begin to dissolve. I once waxed an elaborate pattern on stretched silk noil, then painted it with acid dye. I watched sadly as the melting design disintegrated before the cloth dried. Silk charmeuse (16mm) works well, although 16mm silk jacquards generally do not work as well. Habotai (8mm) allows a fairly crisp edge to the waxed image. Surprisingly, soy wax works well on silk/rayon velvet as long as the strokes are kept fairly wide. On velvet, I usually apply the wax generously from the back.

Dye process:

Direct application is imperative; prolonged immersion dissolves the wax (exception: see my interview with Kathleen Theriault below). Any dye left on top of the wax will partially penetrate it; if it is puddled it will actually dissolve the wax. This can result in interesting effects—a partial resist. Or, if one layer is dyed, and then a second layer is waxed and overdyed, the second color may penetrate the original waxed area and give a true color rather than an overdyed blended color. Sometimes the second layer of wax does not adhere well to the first layer and sloughs off. This may be because soy wax appears to shrink more than paraffin when cooled.

Fig. 1. Soy pastilles and soy slab with USA dollar coin.

Soy Wax Removal:

When using acid dyes or Procion H dyes which require steaming, it is best to iron out as much wax as possible before steaming. (Place fabric between several layers of clean paper, etc.) More wax is removed during the steaming process, particularly if several layers of paper are used. After steaming acid-dyed silk, a wash in warm water with Synthrapol, followed by thorough rinsing in warm to cool water, removes most if not all of the wax. When washing out after using Procion H dye, follow the standard directions of first rinsing in cool water to remove the soda ash and urea and then finish by very hot washing with synthrapol. Heavier fabric may still require dry cleaning to remove an oily residue, although I have found that silk/rayon velvet seems fine without this.

Storage:

As with all waxes, soy wax should be stored away from heat and, since it is water soluble, away from moisture.

Environmental benefits:

Soy wax is biodegradable and is made from a renewable resource, as opposed to paraffin which is a non-renewable petroleum product. If it can help avoid use of dry cleaning chemicals this is another "green" benefit.

Safety of soy wax:

While looking into the safety factors for soy products, I came across many studies citing negative health effects related to a soy-rich *diet,* but no studies indicating health risk in working with heated soy wax. Fumes from burning soy wax candles have been tested and compared with fumes from burning paraffin candles. The soy fumes are cleaner.[6] The soy wax Materials Safety Data Sheet (MSDS), excerpts of which are included in Appendix 2, warns only of obvious hazards, such as burns or overheating the wax. As with all wax, good ventilation is important. (The MSDS for paraffin[7] warns not to inhale the fumes and lists potential health risks associated with this material.)

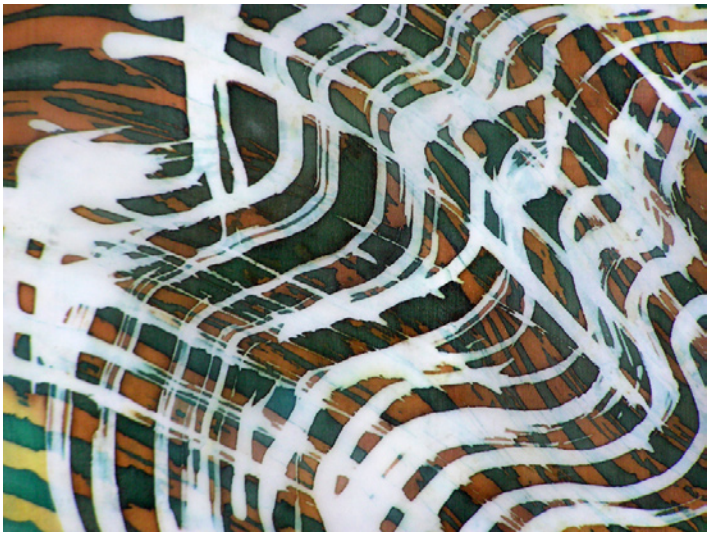

Fig. 2, top. Soy wax on habotai silk, 2 layers of acid dye.

Fig. 3, center. Same technique as above.

Fig. 4, bottom. Soy wax on charmeuse silk, 1 layer of acid dye.

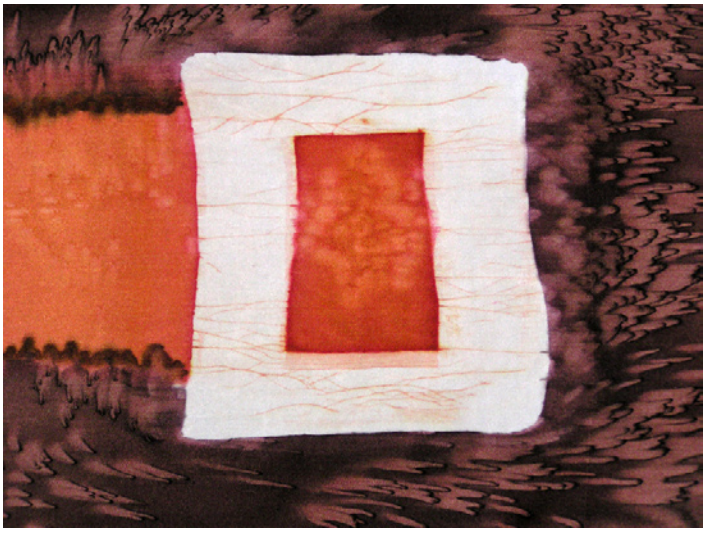

Fig. 5, above. Soy wax crackle on charmeuse silk, 2 layers of acid dyes.

Studio Experiments:

1. Soy wax was applied to stretched lightweight silk, then acid dye was brushed over it. More wax was applied, and a deeper color dye was brushed on. When dry, the piece was ironed between layers of paper to remove most of the wax. The dyes were then set by steaming, after which the piece was washed in warm water with synthrapol. *(Figs. 2–3)*
Results: good edges to the wax strokes, original hand (softness) was restored to the silk after washing and ironing.

2. Wax was applied to silk charmeuse in several layers, then the fabric was wrinkled to crack the wax. Dye was applied over the entire piece, including the waxed areas. Once the dye had penetrated the cracks, it was wiped off of the wax. Another layer of wax and dye were applied. *(Figs. 4–5)*
Results: Fairly crisp crackle lines, good edges to the waxed design, and good hand after washing. I have produced many scarves with soy wax / acid dye on habotai and charmeuse, usually doing only one or two layers of wax/dye. This does not work as well with 16mm jacquard silk, perhaps because the weave allows more wicking of moisture.

3. Soy wax was applied in an intricate design to silk noil, then dyed with acid dye.
Results: Much of the wax dissolved before the noil was dry, allowing the dye to bleed into the design. This failure with silk noil was partly due to the unforgiving nature of my design.

4. Silk/rayon velvet scarves were immersion-dyed with Procion MX and dried. Soy wax was brushed, stenciled, and spattered onto the reverse side to make designs. Then the velvet was stretched and painted from the reverse side with liquid Procion H dyes. Sometimes the dye was carefully brushed around the waxed areas and sometimes just flooded over the entire waxed design. *(Fig. 6)*

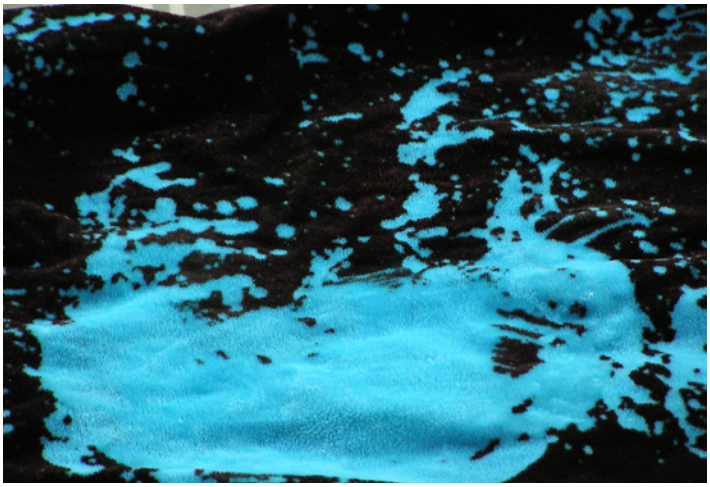

Fig. 6. Soy wax and Procion H dye on silk/rayon velvet.

Results: As expected, dye does begin to penetrate the design if left on top of the wax, but this can produce interesting effects. Drying took hours, even sometimes overnight, but the soy wax held up well. The wax was ironed out before steaming and several layers of paper were used in the steamer roll. Outcome was excellent, although on this napped fabric the design edges were soft. Dry cleaning was not required.

Figs. 7–9. Beeswax 40%, soy wax 60% by weight; landscape in Rozome technique on kimono silk.

5. Soy wax was mixed with beeswax in a proportion of 1 part beeswax (8 oz) to 4 parts soy wax (2 lb). This was an effort to increase the water resistance of the soy wax without using paraffin. Since adding beeswax will make drycleaning necessary, the only advantage to this process would be avoiding the use of paraffin. I set up this dye experiment by stretching kimono silk on wooden stretchers with *shinshi,* then applied a layer of *gojiru*[8] (my rozome technique). The stretched silk was dried, waxed in three layers, then moistened again. The dye was applied with Japanese *surikomi* brushes in a scrubbing motion. *(Figs. 7–9)*

Results: The soy wax/beeswax mixture brushed on beautifully. The wax was not sticky, as with a heavier beeswax/paraffin mixture. Usually I apply wax once on the back of the fabric and twice on the front. Unfortunately, the soy/beeswax mixture did not adhere well to the previous layer. After one dyeing, I scraped off the loose wax, increased the beeswax content to 40%, and rewaxed before dyeing again. There was minimal bleeding at the waxed edges and some crackle due to the flexing of the silk during the rigorous dyeing process. After numerous layers of dyeing and waxing, the wax was ironed out between papers and the piece was steamed. Although much of the wax was removed in steaming, unfortunately it still required dry cleaning.

Fig. 10. *Morning Glories,* by D. Bowen. 53x51 cm. Rozome (soy wax 50%, beeswax 50%, acid dyes on kimono silk).

In more recent work *(see Fig. 10 above)* I have increased the content of beeswax to 50%, in hopes of reducing crackle and increasing adherence of the wax to previous layers. This is the mixture which I use to teach rozome, and it works well. Students love working with it. This method does not avoid dry cleaning, but it does eliminate the use of paraffin.

Soy Wax in the Studios of Other Artists

Since I initiated a discussion about soy wax in an internet group on November 2, 2002,[9] many artists around the world have taken up the challenge to experiment with it. Some have embraced it, using it when teaching as well as for their own work. Others tried it and were disappointed that it did not have the same resistance to water as paraffin and beeswax. True, it is NOT the same.

Our discussions rage back and forth, debating the "greenness" of soy itself. As with most environmental issues, the options are not colored in black or white. Grown first in China 5000 years ago, soybeans have become a major worldwide food and oil crop. Since the late 1980's Monsanto has added a gene to soybeans which gives resistance to their pesticide *Roundup,*® so that "weeds" in the sprayed field will be killed leaving the *Roundup Ready*® soy plants unaffected.[10] Now 80% of the soybeans grown in the USA and 55% of the world's soybeans are genetically modified (GMO) crops.[11]

Nonetheless, a number of artists who wish to avoid paraffin have adapted their batik technique to soy wax. One, **Kathleen Theriault,** had a piece shown in the Wax Eloquent Exhibit at the World Batik Conference in Boston in June, 2005.

When I visited Kathleen in her Colorado studio in September 2005 she discussed her switch to soy wax. A batik artist for many years, she had become sensitized to paraffin fumes. Rather than give up her favorite medium, she decided to try soy wax. Kathleen creates exquisite landscapes, portraits, and other compositions using many layers of Procion MX dyes and wax on cotton. Although her batik is ultimately mounted and framed under glass, she still washes it thoroughly, making certain the dyes are colorfast. She sometimes washes out the wax between each dyeing and finds that the next dyes take well. In her dyebath technique, she simply leaves the waxed piece immersed for a shorter period of time to avoid losing her resist, cutting way back on salt and soda ash. She has figured out how to make this process work for her so that the soy wax does not dissolve yet the dyes withstand repeated washings.[12]

Kathleen Theriault has shown that immersion dyeing can be adapted to work with soy wax—despite its solubility in water.

Well-known artist **Betsy Sterling Benjamin** has experimented with soy wax and included several of these pieces in her show at the 2005 World Batik Conference in Boston. Betsy's summary of this work is included with her permission in Appendix 1 of this paper.

Following a workshop I led for members of the New Mexico Silk Painters Guild, several artists showed soy wax pieces in our recent show. **Mildred Woodrow** and **Beverly LaZar** have produced vibrant framed silk art as well as elegant scarves and ruanas, none of which required dry cleaning to remove the wax.

Recommended Uses for Soy Wax as a Resist:

Soy wax by itself has not yet replaced beeswax and paraffin in my studio, but it has definitely found a place of its own. It is wonderful to be able to produce silk scarves for shows and galleries without the expense and inconvenience of dry cleaning.

Soy wax is a great way to introduce students to the idea of batik without the mess of dyebaths. We can do several layers on silk, using acid dyes applied with brushes, then iron the silk between papers to remove excess wax before steaming. Students have been enthusiastic and have made beautiful pieces. While many have complained of paraffin fumes[13] in classes (even outdoors), no one in my classes has yet been bothered by soy wax fumes.

Figs. 11–12, above. Students discovering soy wax.

Fig. 13, below. Chimney Rock, Ghost Ranch, Abiquiu, NM.

During the summers I teach in an outdoor high desert venue, Ghost Ranch, in Northern New Mexico *(Figs. 13–14)*. Water is scarce there, so we are not allowed to do full immersion batik. Disposal of dyebaths is a problem as well, since they do not want dyes poured onto the ground or into the septic system.Because batik is my first love, I have usually included a few lessons in wax resist during the silk painting classes. Unfortunately, with paraffin and beeswax, this meant that I had to take all student work home at the end of the week, send it to the dry cleaner, then mail it back to them.

With soy wax, students can wash the pieces after steaming, hang them in the class show, and take them home ready to frame or wear. Ghost Ranch is happy to have a more environmentally friendly workshop, and the students enjoy working with soy.

Conclusions:

Soy wax is a relatively new material which deserves serious consideration by the batik artist. While it does not behave exactly like the traditional batik waxes, and is not suitable for immersion techniques, it can be useful in classroom settings where generous ventilation may be difficult and where dry cleaning is not easily accomplished.

Use of soy wax is promising as a resist for the batik artist who wishes to remove wax from fabric in the studio, perhaps between each dyeing. For the artist who is sensitive to paraffin fumes, it could serve as a substitute for paraffin when mixed with beeswax for a more water-resistant and pliable resist than soy wax alone.

Artists should try to keep themselves informed about current research involving the toxicity of chemicals to which they expose themselves in the studio. For the batik artist, this includes wax fumes. I believe that we also have a responsibility to consider the effects of our processes on the health of others and on the environment. Perhaps another means of removing wax from silk will be developed, but until that time, it seems best to minimize the use of perchloroethylene by reducing one's dependence upon dry cleaning.

Soy wax may be part of the solution, especially since industry regulations are making continued reliance on this chemical impossible.

I believe that we also have a responsibility to consider the effects of our processes on the health of others and on the environment.

Fig. 14. Ghost Ranch, with the famous New Mexico landmark *Pedernal* in background.

Appendix 1:

The following is a communication sent by Betsy Sterling Benjamin, who has also been experimenting with soy wax as a resist in rozome, a Japanese form of batik. She has graciously agreed to allow me to include it to present another set of observations.

SOY WAX NOTES

Betsy Sterling Benjamin

Ideal temperature is low/ 170F

Application:

1. Soy is much thinner than blended waxes and is more likely to drip when carrying wax from the pot to the fabric
2. The wax brush cools quicker in the air. *Carry the hot wax to your fabric quicker than with other waxes. * Move your work as close as possible to your wax source. *Cover areas that are not being worked on with a piece of newspaper to prevent splashing or dripping.
3. Penetration of the fabric is more difficult. *Carry a saturated brush with more wax on it for complete penetration. *Move the brush on the fabric somewhat slower, to allow for better penetration.
4. Soy wax is a thinner substance than blended waxes and is more likely to 'puddle' on the reverse side of the fabric.

Cover Qualities

1. Soy has less tackiness and lacks the 'sticking' power of blended waxes**.**
2. It is hard to make a strong edge to resist dye. * A second coat of wax is possible for better cover, however, the two layers often do not bond and there is seepage of dye between the layers.

Cracking Qualities

1. Soy wax cracks very easily if the fabric is moved.
2. Chips from cracked soy wax on the surface of the fabric attract dye and speckle the dyed surface almost like a salt treatment.

Dyeing

1. Immersion dyeing not advised
2. Dye applied over the soy wax tends to discolor the wax and allows a haze of color to penetrate.
3. Wiping off the soy wax to remove surface dye is difficult.
4. Waxing and dyeing from one side allows for a cleaner white resist on the reverse**.**

Appendix 2:

Excerpts from MSDS for soy wax provided by Enchanted Lites

The complete MSDS is available from Enchanted Lites
and should be consulted before use of their product.

MATERIAL SAFETY DATA SHEET

MSDS No.: EL-31 EL 31 Votive Wax
Revision No.: 1 Date: 4/22/03
Manufacturer/Distributor:
Enchanted Lites, 375 Industrial Ave, New Hampton, IA 50659, 866-345-2204

COMPOSITION INFORMATION
Chemical Name: Hydrogenated Soybean Oil 85%; CAS Number 8016-70-4
Emulsifiers (proprietary) 15%
Exposure Limits: Oil mist (mineral): OSHA PEL: TWA 5 mg/m3

OSHA REGULATORY STATUS
While this material is not classified as hazardous under OSHA regulations, this MSDS cotains valuable information critical to the safe handling and proper use of the product.
Note: This product may be classified as hazardous under OSHA regulations if handled in liquid form with oil vapors or mist present in concentrations that exceed permissible exposure limits.

HAZARDS IDENTIFICATION
OVERVIEW
Off-white to amber, solid (pellet form) soybean oil based wax.
Presents little or no health hazard. Fine oil mists may be hazardous.
Eyes: Contact with vapors or mist may cause irritation or burning.
Skin: Contact with product is not expected to cause severe skin reaction. May cause irritation. Contact with heated materials may cause thermal burns.
Inhalation: Inhalation of vapors or mist may cause respiratory tract irritation.
Ingestion: Ingestion is not likely to occur under normal handling operations. Ingestion of large amounts of product may cause digestive irritation.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE:
Existing respiratory conditions.

CHRONIC HEALTH EFFECTS:
Eyes: Repeated eye exposure may cause prolonged irritation.
Skin: Contact with product is not expected to cause severe skin reaction. Repeated or prolonged contact may cause irritation.
Inhalation: Repeated inhalation may cause respiratory tract irritation.
Ingestion: Repeated ingestion is not likely to occur under normal handling operations.
Prolonged ingestion of product may cause digestive irritation.

HANDLING & STORAGE
Handling: Avoid contact with skin, eyes and clothing. Avoid breathing vapors or mist, if present. Utilize good housekeeping and personal hygiene practices.

Appendix 2, Soy Wax MSDS, continued

EXPOSURE CONTROLS / PERSONAL PROTECTION

ENGINEERING CONTROLS: General ventilation of the area should provide adequate control when handling this product.

PERSONAL PROTECTIVE EQUIPMENT:
Eye/Face Protection: Utilize chemical goggles or face shield if handling this product in a manner that may cause eye/face contact.
Skin Protection: Wear chemical resistant gloves and appropriate clothing to avoid excessive skin contact.
Respiratory Protection: If exposure limits exceed the recommended levels, wear NIOSH/MSHA approved respirator.
General Hygiene Considerations: Contaminated clothing should be removed and washed thoroughly. To protect skin and eyes from excessive contact, safety showers and/or eye wash stations should be available. Other Protective Equipment: None recommended.

EXPOSURE GUIDELINES: Name: Oil mist (mineral); OSHA PEL: TWA 5 mg/m3
ACGIH TLV: Nuisance Particle

PHYSICAL & CHEMICAL PROPERTIES
CONSTITUENT: EL 31 Votive Wax
Boiling Point----------> 500o F
Melting Point ----------156-183o F
Vapor Density (Air=1) ----------N/A
Specific Gravity (H2O = 1) ----------0.92

DISPOSAL CONSIDERATION
Hydrogenated soybean oil is not listed as a regulated RCRA hazardous waste. Dispose of in accordance with local and state requirements.

TRANSPORT INFORMATION
DOT CLASSIFICATION: Not regulated as hazardous under DOT regulations.
IATA CLASSIFICATION: Not regulated as hazardous under IATA regulations.
IMDG CLASSIFICATION: Not regulated as hazardous under IMDG regulations.

OTHER INFORMATION
To the best of our knowledge, the information contained herein is accurate. However, neither Enchanted Lites nor any of its subsidiaries assumes any liability whatsoever for the accuracy or completeness of the information contained herein. Final determination of suitability of any material is the sole responsibility of the user. All materials may
present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist. The possibility exists that the EU will not recognize this MSDS due to the fact that several components of the MSDS are reflective of ANSI Z-400.1-1998. Although ILO (International Labor Organization) has adopted ANSI Z-400.1-1998, ultimate disposition lies with the competent authority.

Appendix 3:

Suppliers for soy wax

The internet is an excellent source to find suppliers in your area

Bitter Creek Candle Supply
Ashland, WI, USA
877-635-8929 or 715-278-3900
www.bittercreek.net

Bitter Creek South Candle & Soap Supply, Inc
Contact: Ellen
Ph: 281-277-4440
E-mail: info@bittercreeksouth.com
www.bittercreeksouth.com

Calwax Corporation
Irwindale, CA, USA
Ph: 626-969-4334 x 224
www.calwax.com

Canada Waxes
Mississauga, Ontario, Canada
905-602-1500
www.canwax.com

Candleworks
1029 Third Street S.E.
Cedar Rapids, Iowa 52401, USA
Phone: 319-363-1774
Fax: 763-374-4513

Candle Soylutions
Muskogee, Oklahoma, USA
918-681-2800
www.candlesoylutions.com/

Enchanted Lites
New Hampton, IA, USA
Ph: 641-394-6204
www.enchanted-lites.com

Full Moons Cauldron
PO Box 2173
Ascot, Berkshire SL5 0PQ
United Kingdom
Ph: 01344 627 945
http://www.fullmoons-cauldron.co.uk

Gelluminations
Spirit Lake, IA, USA
Phone: 866-748-8949
www.creativeilluminations.com
Email: gelglow@ncn.net

Lone Star Candle Supply
5800 Park Vista Circle
Keller, TX 76248, USA
Ph: (817) 741-0876
Fax: (817) 741-0879
www.lonestarcandlesupply.com

NatureWax™ Premium Candle Waxes
Cargill, Minneapolis, MN, USA
Steve Russell: 866-242-9299

Phytowax
Cedar Rapids, IA, USA
Mike Richards: 888-511-5177
www.soyawax.com

Village Craft & Candle
166 Queen St E
St Marys, ON, Canada
877-668-6603
www.villagecraftandcandle.com/

End Notes

[1] "Health effects associated with exposure to perchloroethylene include depression of the central nervous system; damage to the liver and kidneys; and impaired memory, confusion, and dizziness. There is increasing evidence of human carcinogenicity. The uncontrolled use of PERC has the potential to cause widespread harm to the health of the workers, the people living near drycleaning shops, the general public, and the global environment." Control of Health and Safety Hazards in Commercial Dry Cleaners, the National Institute for Occupational Safety and Health, December 1997, DHHS (NIOSH) Publication No. 97-150, 1998. Report available at http://www.cdc.gov/niosh/97-150.html, accessed April 15, 2005.
Other information regarding the ongoing research about potential hazards with perchloroethylene may be found at The European Chlorinated Solvent Association web site, http://www.eurochlor.org/chlorsolvents/about/about.htm, accessed April 16, 2005.

[2] Iowa Soybean Promotion Board website, http://www.iasoybeans.com/ispb/soycandles/schistory.html, accessed April 16, 2005.

[3] "Hydrogenation is used to solidify soybean oil to manufacture margarine and soybean oil shortening. Hydrogen is infused through soybean oil at a controlled temperature, changing the chemical and physical structure of the oil until it will solidify at room temperature." New Mexico State University, http://darwin.nmsu.edu/~molbio/plant/soybean.html, accessed April 16, 2005.
"Hydrogenation is the process whereby the poly- and monounsaturated oils are solidified in order to increase the viscosity. This is done by reaction of hydrogen with the oil at elevated temperature (140-225°C) in the presence of a nickel catalyst." http://www.soya.be/soy-wax-production.php, accessed April 16, 2005.

[4] The Iowa Soybean Promotion Board, http://www.soyawax.com/, accessed April 16, 2005.

[5] Bitter Creek Candle Supply, http://www.bittercreeksouth.com/waxes.htm, accessed April 15, 2005.

[6] "Soywax…was investigated for its tendency of producing soot and potentially harmful organic volatiles (e.g. acrolein, formaldehyde and acetaldehyde) during candle burning. While a considerable amount of soot was produced from the combustion of paraffin candles under disturbed condition (simulated air movement), little or none was observed from soywax candles. Low level of formaldehyde was detected in paraffin candle fume, but it was not present in significant quantity in the soywax candle fume. Acrolein was not detected in either type of candles." *Ibid,* Iowa Soybean Promotion Board website. Research results reported in: Rezaei, K., T. Wang, and L. A. Johnson, Hydrogenated vegetable oils as candle wax, *J. Am. Oil Chem, Soc.* 79: 1241-1247 (2002), and Rezaei, K, T. Wang, and L.A. Johnson, Combustion characteristics of candles made from hydrogenated soybean oil, *J. Am. Oil Chem. Soc.* 79: 803-808 (2002).

[7] To view a copy of the MSDS for paraffin wax, visit http://www.sciencestuff.com/msds/C2200.html, accessed April 18, 2005. It warns not to inhale fumes, to use a NIOSH/MSHA-approved respirator, and notes that this material has not yet been fully investigated. Target organs are "lungs, throat, upper respiratory, kidney and bladder. Conditions aggravated/target organs. Persons with pre-existing eye, skin or respiratory conditions may be more susceptible."

[8] *Gojiru* is made by blending dried soybeans which have been soaked overnight with water, then straining the mixture and diluting it until the submerged hand is visible one inch below the surface.

[9] Waxeloquent1 is a Yahoo discussion group begun September 12, 2001, by students of Betsy Sterling Benjamin "for all persons passionate about roketsuzome and batik and the magical properties of wax, dye, and fiber."

[10] TED Case Studies, The US & EU Trade Dispute Over GMO Soybeans. American University website http://www.american.edu/projects/mandala/TED/soybean.htm, accessed November 29, 2005.

[11] Genetically Modified Soybeans And The Patent System, TED Case Studies Number 769, 2004, by Itaru Nitta. American University website http://www.american.edu/ted/soybean-patent.htm accessed November 29, 2005.

[12] Interview with Kathleen Theriault in her studio September 1, 2005. Her lovely batik can be seen at http://www.k-theriault-fineartbatik.com/.

[13] While the US National Institute for Occupational Safety and Health does not at present recognize inhalation of paraffin fumes as toxic, it does note the following symptoms: "Irritation [of] eyes, skin, respiratory system; discomfort, nausea." NIOSH Pocket Guide to Chemical Hazards, Publication No. 97-140, February 2004. Report available at http://www.cdc.gov/niosh/npg/npgd0477.html, accessed April 17, 2005.