Biodiesel Produced from Jatropha Seed Oil

Project Proposal and Feasibility Study

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Executive Summary

Team Oil from [the] Soil is comprised of a group of senior chemical engineers at Calvin College who are proposing an alternative method to producing biodiesel. This alternative entails converting the oil found in seeds from the *Jatropha Curcas* plant into biodiesel. Team Oil from [the] Soil plans to design and optimize a full scale plant that extracts and converts the oil found in Jatropha Curcas seeds into a usable diesel fuel substitute. In addition to this, the team plans to build a simplified prototype to demonstrate the entire process.

Using the Jatropha seed oil to produce biodiesel has been found to be a feasible option because:

- The yield of biodiesel per hectare for Jatropha is more than four times as much fuel per hectare as soybean, and up to ten times that of corn
- The Jatropha plant is a non-food plant and would not consume any food stock.
- The Jatropha plant can be grown in harsh, arid conditions, making it suitable for growth in many different and difficult environments.
- Jatropha plantations and biodiesel production has the potential to boost the income of less developed countries with vast wastelands.

The producing of biodiesel from Jatropha Curcas seeds has been broken down into two major steps:

1. Extraction of seed oil:
   This requires a high yield chemical procedure to extract the oil from the Jatropha seeds. It has been decided that hexane solvent extraction is the most feasible method of extraction.

2. Conversion of seed oil to biodiesel
   This step utilizes the transesterification process, it is the most effective and feasible method to produce the biodiesel using the extracted Jatropha seed oil.

Team Oil from [the] Soil has created this report to explore the processes that will be used in the project, and the parameters that govern the overall feasibility of the project.
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1. Introduction

1.1. Problem Statement
Although ethanol has been commercialized for use in vehicles, its feasibility as an alternative fuel source to conventional gasoline is growing more unlikely because of the effects it has on the demand for corn and the effects it has on the price of corn. An alternative to corn based fuel is Jatropha derived fuel, based on the Jatropha Curcas plant. Jatropha is an oil-seed bearing shrub that possesses two primary needs for an alternative fuel source: it is a non food plant and it can be grown in harsh, arid conditions where other seed-bearing plants cannot.

1.2. Objectives
The primary objective of this group is to design and optimize a full scale chemical plant that extracts and converts the oil found in Jatropha Curcas seeds into a usable diesel fuel substitute. In addition to this, a simplified prototype for the plant will be created to demonstrate the chemical processes.

1.3. Scope
The plant will be designed to produce 2,000,000 gallons of biodiesel per year, and will be simulated and optimized using UniSim simulation software. The production of the biodiesel from the Jatropha Curcas seeds has been broken down into two main steps:

1. Extraction of seed oil
2. Conversion of the seed oil to biodiesel

High yield chemical procedures will be used to extract the oil from the Jatropha seeds and then to convert that seed oil to biodiesel. Solvent extraction and the transesterification processes are two known chemical processes that give high yields when compared to alternative options. These processes will be incorporated into the design.

The group has placed several restrictions on what the prototype system will accomplish. The extraction of seed oil and conversion to biodiesel will be scaled for a batch size of no more than 5 gallons. Greater sizes will require a significantly greater cost and possibly greater complexity. This group does not plan to do anything more with the waste products from the reactions in the prototype beyond ensuring they are properly disposed of. Although there are many potential uses for these products, the focus of this group is the production of biodiesel.
2. Background

2.1. Jatropha Curcas History
Jatropha is a genus of over 100 plants, shrubs and trees. It is native to Central America and has become neutralized to many tropical and subtropical areas, including India, Africa, and North America. Originating in the Caribbean, Jatropha was spread to Africa and Asia through trading as a valuable hedge plant.

Since Jatropha was introduced into the subcontinents over 500 years ago by Portuguese sailors, hundreds of sub-species have developed through cross-fertilization and adaptation to the subcontinent’s with varied climatic conditions. As a result, Jatropha oil yields and growing characteristics vary from region to region. Research on the qualities and characteristics of Jatropha varieties that flourish in different locations has been done as well as micro-propagating for mass production of seedlings with necessary characteristics for each planting area.¹

2.2. Jatropha Curcas Life Cycle and Harvest
The mature Jatropha plant bears separate male and female flowers, and does not grow more than 5 meters tall. The size of the Jatropha plant kept less than 1 meter tall by hedging; this is convenient for the collection of seeds, as farmers can harvest the seeds with little effort. Jatropha plants are typically harvested between December and January and can produce seeds with high oil content (30 - 40%). Plants are able to produce seeds between 1 and 5 years depending on soil fertility and rainfall, and continue to produce seeds for more than 20 years.² The Jatropha plant is hardy, and can grow in harsh conditions on low fertility soils, in low and high rainfall areas. Figure 2-1 below show a picture of developed Jatropha tree, approximately four years old.

![Figure 2-1. Developed Jatropha Curcas Tree³](http://worldisgreen.files.wordpress.com/2008/03/toil-jatropha-may2007.jpg)

³ <http://worldisgreen.files.wordpress.com/2008/03/toil-jatropha-may2007.jpg>
Figure 2-2 above depicts the developed Jatropha seeds on the plant. The Jatropha plant yields more than four times as much fuel per hectare as soybean, and more than ten times that of corn. One hectare of Jatropha produces approximately 1,900 liters of fuel.\(^5\)

**2.3. Current and Ongoing Business Ventures**

Jatropha Plantation has been identified as a thrust area for the initiation of projects to capitalize on its vast potential. Emerging economies with unproductive lands and tropical climates have looked towards Jatropha cultivation as a way to benefit greatly from the renewable energy resources it provides. Jatropha plantation has been focused on India and several African nations so far, and has the potential of growing in any tropical nation.

Possibly the largest Jatropha investment so far, is D1’s first Indian joint venture with Mohan Breweries & Distilleries Limited, a leading Indian brewer based in Chennai, Tamil Nadu. The companies created D1 Mohan Bio Oils Limited in 2006, and began planting Jatropha in southern India on a contract farming model with financial support for farmers provided in the form of loan finance from Indian banks. A cumulative target of five million hectares was set to be planted over a five year period and planting operations are now carried out by a joint venture with BP, D1-BP Fuel Crops Limited.\(^6\)

**2.4. Other Uses for Jatropha Curcas**

Jatropha Curcas is a multi-purpose commercial crop with its major use in biodiesel production. Apart from biodiesel production, Jatropha can be used to alleviate soil degradation, desertification and

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\(^4\) [http://www.thewoodexplorer.com/maindata/Picts/Jatropha1.jpg]

\(^5\) Michael Fitzgerald. *India’s Big Plans for Biodiesel*. Technology Review; Massachusetts Institute of Technology. 2007. 3 May. [http://www.technologyreview.com/Energy/17940/].

\(^6\) India. n.d. 5 Dec. 2008 [http://www.d1plc.com/globalIndia.php].
deforestation. Also, it can be used for climatic protection and carbon capture, and increasing the income for agro-industries. Glycerin, a byproduct in the production of biodiesel from Jatropha seed oil can be used in soap production and other glycerin based products.

3. Design Considerations

3.1. Biodiesel for Retail
Biodiesel is a domestically produced, renewable fuel that can be manufactured from vegetable oils, or animal fat. Biodiesel is safe, biodegradable, and aids in the reduction of serious air pollutants. Blends of 20% biodiesel with 80% petroleum (B20) diesel can generally be used in unmodified diesel engines. Biodiesel can also be used in its pure form (B100), but it requires certain engine modifications to avoid maintenance and performance problems.

In June of this year the ASTM International D02 Main Committee approved a trio of ASTM specifications for biodiesel blends. The committee approved changes to the existing B100 biodiesel blend stock specification (ASTM D6751); finished specifications to include up to 5% biodiesel (B5) in the conventional petroleum diesel specification (ASTM D975); and approved a new specification for blends of between 6% (B6) to 20% (B20) biodiesel for on- and off-road diesel engines. With the approval of these blends there is now an open market for the production biodiesel.7

3.2. Potential for Farmers and Developing Nations
The benefits for the developing world go further than producing fuel for local use. Since the planting, growing and refining of Jatropha seeds requires manpower, its cultivation will generate large numbers of jobs in areas of low employment. Being a perennial crop, Jatropha can ensure a minimum regular sustenance income to communities that are subject to fluctuations in income streams.

Growing Jatropha as an energy crop can enable developing nations to make use of large areas of marginal and degraded land that have fallen out of production or become unsuitable for agriculture. Jatropha can potentially create millions of rural jobs and increase farm incomes. Jatropha can enable developing countries to obtain supplies of local biodiesel, reducing dependence on expensive imports of mineral diesel, while producing surpluses of refined biodiesel for export.

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4. Alternative Solutions
It is important to consider as many different solutions to the design challenge in the Problem Statement as possible. The final design is essentially the summation of many different designs, specifically the chemistry, the reactors, the separations equipment, and the process equipment such as compressors and pumps. Analysis of the alternatives will be done on the two main steps outlined in the Scope previously.

4.1. Extraction of Seed Oil Alternatives
Three alternatives for extracting the Jatropha seed oil are:

1. Mechanical press
2. Ultrasonification
3. Solvent extraction

Of these, the most common way of extracting the Jatropha seed oil is through a mechanical press, either manually or electrically powered. This process is not very efficient, with only about 50-60% of oil being extracted from the seed, and the rest being left in the seed residue. Also, the high heat generated from pressing can damage the oil and reduce the overall yield. Ultrasonification is another option that has been considered as an extraction method. Ultrasonification entails the use of high intensity acoustic energy to change materials, which can improve the mixing and separation in various processes. This technique however, requires a greater degree of work and a high degree of knowledge on how the required machinery works. The solvent extraction process utilizes a solvent to extract the oil out of the seed. There are many chemicals that can be used as a solvent to extract oil, for example hydrocarbon solvents (hexane), halogenated solvents (trichloroethylene) and supercritical solvents (supercritical CO₂). Hexane has an extraction grade of 48-98% with a narrow distillation range.

These methods have been analyzed in the Feasibility Study section (5.2) to determine the best extraction alternative.

4.2. Conversion of Seed Oil to Biodiesel Alternatives
There were various other mechanisms for transesterification that were looked into: supercritical methanol, Ultra-shear inline, Ultra-sonic, and Microwave reactors. Each of these methods tries to maximize the contact with the two immiscible fluids or increase local heat at the interface between the two fluids in the

reactor. When the interface is heated or contact is maximized the Transesterification reaction can proceed at a higher rate.

These various options were judged carefully and thrown out for the following reasons: supercritical methanol had the danger of running at both high pressure and temperature, ultrasonic reactors had very little reference in literature, microwave reactors showed some promise but remain an unproven technology, and ultra-shear reactors were outside of the price feasibility of this project. So a simple transesterification methanol and catalyst reaction was chosen.

5. Feasibility Study
The parameters that dictate the process design are: the amount of time available to accomplish the design, the extraction and conversion steps which govern the process, and the resources available to the team. These parameters will be analyzed in detail below.

5.1. Time Feasibility
This project, while very challenging, will be feasible in the given time frame. Since most of the chemicals used in this process can be found in the UniSim modeling software, the team will be able to create a computer simulation of the process. The challenge of the design will be in determining the kinetics of the reactions involved. Most of the research will be done to determine the optimal size, shape, operating temperatures and sizes of the equipment in the design.

5.2. Extraction of Seed Oil Feasibility
To outline the feasibility of the method of extraction for the process, it was necessary to determine the best method of extraction. A decision matrix was created to determine the most feasible option. The extraction methods outlined previously in the Alternative Solutions section were studied to determine the best alternative for the team use. Results of the study are shown in the decision matrix below.

<table>
<thead>
<tr>
<th>% Yield</th>
<th>Weight</th>
<th>Mechanical</th>
<th>Ultrasonification</th>
<th>Hexane</th>
<th>Trichloroethylene</th>
<th>Supercritical CO2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Method</td>
<td>8</td>
<td>0.2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Small to Large Scale</td>
<td>1</td>
<td>0</td>
<td>0.5</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>1</td>
<td>0.5</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Safety</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Cost</td>
<td>4</td>
<td>0.5</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>9.6</td>
<td>10.5</td>
<td>17</td>
<td>14</td>
<td>12</td>
</tr>
</tbody>
</table>
Table 5-1 shows that hexane solvent extraction is the most feasible extraction process for this project. The hexane solvent extraction method is practiced on a wide scale and is used in general laboratory chemistry. Hexane is free of nitrogen and sulfur, and sufficiently stable to be used indefinitely. In addition to this, hexane is the only solvent from this list that is used in large scale operations.\textsuperscript{10} Hexane is also relatively cheap and easily attainable, and will be used as the extraction method for the design.

5.3. Conversion of Seed Oil to Biodiesel Feasibility
The transesterification process has been chosen as the step to convert the Jatropha seed oil to biodiesel. Reasons for choosing the transesterification process are: ease of use, literature availability and budget. The chemicals used in the transesterification process a easily attainable and are used widely in industry. The transesterification process is a standard method for converting natural oils to biodiesel, and there exists a wide range of information that is easily attainable. In addition to this, the chemicals used are general laboratory chemicals, those which can be ordered through the Chemistry Department.

Preliminary analysis shows that this process will be able to successfully convert the seed oil from Jatropha. In addition to this, others have used this process to convert Jatropha seed oil, and have successfully yielded a biodiesel product. The team is

6. Preliminary Design
6.1. Chemistry Overview

6.1.1. Extraction of Seed Oil using Hexane
Hexane has been chosen as the method of extraction. Care has to be taken to prevent any emission of hexane from the closed system because it is toxic. The hexane can be recovered and reused again in the extraction process.

Extraction will be done in a batch-wise operation for the extraction process. The Jatropha seeds will be grinded up to increase the surface area that will come into contact with the hexane solvent. The ground up Jatropha seeds will then be placed in a batch reactor and hexane will be added into the reactor. The solvent will be allowed to contact the seeds for about 20 minutes. Then, the liquid mixture will be

removed from the batch reactor and the solvent will be distilled out of the mixture. The seed cake left in
the reactor will contain some solvent that can be reused.

To recover the hexane, steam can be introduced to the seed cake, which will evaporate any remaining
solvent out of the cake. The steam and hexane mixture will then be condensed and collected in a decanter
where they will separate, due to their difference in densities. The hexane can then be collected and
recycled in the extraction process again.\(^\text{11}\)

6.1.2. Conversion of Seed Oil to Biodiesel: Transesterification Process
Nearly all natural plant oils are composed entirely of mono, di, and tri-glycerides, which through the
 transesterification pathway can become biodiesel. Biodiesel is a combination of medium to long chain
 esters that have very attractive properties as a renewable fuel. They are stable at ambient temperature,
burn cleanly, and usually have very low sulfur compared to petroleum diesel.

Most industrial applications of transesterification are carried out using a base catalyzed reaction with
NaOH and methanol. Base catalyzed reactions are preferred because the acid catalyst mechanism
requires high heat and long reaction times. Traditionally the NaOH is first solvated in the methyl alcohol
before being added to the process. There are two main reasons why the NaOH is added first, one is
because it deprotonates the alcohol prior to insertion into the medium and secondly is because it
simplifies the mixing of the base catalyst into the immiscible source oil. Once the alcohol/catalyst mixture
is added to the source oil the reaction proceeds as follows:
1) First the alcohol is deprotonated with the base:

\[
\text{ROH} + \text{NaOH} \rightarrow \text{RO}^- + \text{H}_2\text{O} + \text{Na}^+
\]

2) Then the carbonyl is attracted by a slight positive charge on the triglyceride:

_Suitability_of_solvent_extraction_for_jatropha_curcas.pdf>
3) Next, the unstable tetrahedral intermediate breaks up into a di-glycerol and an ester.

4) Finally, this process is repeated with two more RO groups to yield a glycerol and two additional esters. The overall reaction is shown below.

If water is present in the feed stock the reaction may emulsify and not proceed to completion. The transesterification reaction requires water content to be ≤ 1% by weight of vegetable oil. Fortunately the water content of Jatropha oil is said to be ≤ .1% mass water. Although the initial concentration of the water is not harmful, care must be taken that the methanol recycles are free of water so that risks are minimized.

Free Fatty Acids (FFA) are also a concern for this transesterification method as they will consume the base catalyst and form soap. Unfortunately FFA’s are dependent on both the age and the location of Jatropha plant when it is grown. Although research has shown that some FFA can be tolerated by inputting surplus methanol and catalyst in the reaction which is advisable for this case.

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The transesterification process will take place in the reactor and once the biodiesel has been created, it will be passed through a series of processes to separate is from the byproducts and leftover reactants. Figure 6-2 below shows the process for the production of biodiesel via the transesterification process.

![Diagram of transesterification process]

**Figure 6-2. Production of Biodiesel using Transesterification Process**

This figure shows the reactants being placed into a batch reactor where the transesterification reaction takes place. The product from the reactor is taken through a series of separations units. These separations steps separate the biodiesel from the byproducts and leftover reactants.

By incorporating both the hexane extraction and the transesterification processes a preliminary process flow diagram can be drawn. A preliminary process flow diagram for the overall process has been procided and may be found in Appendix B.
7. Safety
In addition to observing general chemistry laboratory safety precautions, the safe handling and storage of all chemicals involved in the prototype of the Jatropha extraction and treatment processes must be considered. Material safety data sheets are available for review in Appendix B of this report.

7.1. Hexane Safety
The highly reactive and flammable nature of hexane requires that consideration be given to its proper storage techniques. Exposure to air will form explosive mixtures, so an air-tight container should be used, located away from oxidizing agents, chlorine, and fluorine. Prolonged exposure to hexane may cause serious health effects, and acute exposure has been proven to cause infertility and respiratory conditions. Individuals involved in the use of hexane should ensure that all sources of ignition are eliminated and that a well-ventilated work space is utilized. Safety goggles, chemical resistant clothing, and gloves are recommended.

7.2. Methanol Safety
Methanol, especially hazardous when in a vapor phase at low temperatures, is extremely flammable in all phases. Solutions combining methanol and water also present a flammability hazard. Methanol should be stored away from heat, spark, and flame sources. Depending on the expected airborne concentration, suggested respiratory protection ranges from no protection to a self contained breathing apparatus during extended exposure. Due to the risk of skin damage incurred from prolonged exposure, boots, gloves, and chemical resistant clothing are suggested for individuals working near methanol. Goggles and a face shield are also suggested to minimize the risk of eye damage. Any ingestion of methanol may cause significant damage to the human nervous system or death. Additionally, liquid penetration of the skin and inhalation may also cause nervous system damage.

7.3. Sodium hydroxide Safety
Sodium hydroxide should be stored in a tightly closed container and a cool, dry atmosphere. The storage and use of sodium hydroxide should only be conducted in a well-ventilated area. Care should be given that storage conditions are isolated from acids, flammable liquids, organic halogens, metals, and nitro-compounds, as these combinations may cause undesired reactions. Due to the corrosive nature of sodium hydroxide, any contact with skin, eyes, and clothing should be avoided to prevent severe burns. Care should also be given that particulate matter, vapor, or dust from the compound is not inhaled or ingested. To avoid bodily contact, chemical resistant clothing, gloves, goggles, and a face shield are suggested.

7.4. Flammability of Finished Product
With a flash point of over 300°F, biodiesel is considered to be not flammable. The flash points for blends of biodiesel also increase with the increase in percentage of biodiesel in the blend. Comparing that to the
flash point of petroleum diesel, which is about 160°F, biodiesel and blends of biodiesel are a lot safer to handle and store.\textsuperscript{13}

\section*{8. Budget}

\subsection*{8.1. Sources of Income}

As a senior design project team at Calvin College some funding will come from the Engineering Department. The amount provided to each project team is $300. It is projected that the team will be able to complete the project within this budget because the only planned costs are those associated with experimentation and testing the prototype.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|}
\hline
\textbf{Item} & \textbf{Quantity} & \textbf{Comments} & \textbf{Cost} \\
\hline
Jatropha Seeds & 500 & Seed from Jatropha Curcas plant & $25.00 \\
Methanol & 0.5 gallons & (Reagent) Anhydrous, 99.8\% & $24.62 \\
Sodium Hydroxide & 4 lbs. of flakes & (Catalyst) Anhydrous pellets, 98\% & $20.00 \\
Hexane & 1 gallon & (Solvent) & $16.17 \\
\hline
\textbf{Total Costs} & & & $85.79 \\
\hline
\end{tabular}
\caption{Cost Estimate of Required Materials}
\end{table}

Table 8-1 above shows an estimated cost of approximately $86, this cost represents the total cost for this project. It is possible that further down the road some costs may arise if additional materials are needed. The prototype will be constructed using glassware in the chemical engineering laboratory at Calvin.

\subsection*{9. Method of Approach}

Since the process of converting Jatropha seed oil into biodiesel has been determined to be feasible, some path or method must be employed in the design of the process operations. The method of approach to the task of designing a plant is to work backwards from the final goals of the project. First, the final goals of the project were determined. The goal is to design a plant that converts the seed oil produced from the Jatropha curcas plant into a usable diesel fuel substitute.

Second, it was decided what fundamental areas of the design are vital to the overall process. These are the two main processes, solvent extraction of the Jatropha seed oil and the conversion of the seed oil to biodiesel.

Third, which brings us to the current status of the project, is acquiring the information needed to design the reactions and separations. The essential information is a kinetic rate law for the reactions and separation parameters.

Fourth, is the design of the key parts of the process: the reactors and separation units. The other pieces of equipment support these major units, so it is feasible to begin with the most important.

Fifth, is to design the other pieces of equipment to fill in the unknown information for all streams.

Sixth and last, is the optimization of the whole process by modifying operating conditions and equipment to yield the highest.

The small scaled prototype will be constructed and tested during the spring semester, 2009, as the project unfolds.
9.1. Task Breakdown and Time Schedule
The following table outlines the task that have been completed so far and the tasks that to be completed.

Table 9-1. Task Breakdown and Time Schedule

<table>
<thead>
<tr>
<th>Task</th>
<th>Completed Dates*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Objectives Defined</td>
<td>29-Sep-08</td>
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<tr>
<td>Project Poster</td>
<td>30-Sep-08</td>
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<tr>
<td>PPFS outline</td>
<td>6-Oct-08</td>
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<td>First Presentation Delivered</td>
<td>2-Oct-08</td>
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<td>Preliminary Task Specifications</td>
<td>3-Oct-08</td>
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<tr>
<td>Preliminary Evaluation of Feasibility</td>
<td>4-Oct-08</td>
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<tr>
<td>PPFS Draft</td>
<td>7-Nov-08</td>
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<tr>
<td>Refined Task Specifications</td>
<td>6-Oct-08</td>
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<td>Batch Reactors</td>
<td>29-Nov-08</td>
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<td>Chemical Properties</td>
<td>29-Nov-08</td>
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<tr>
<td>Separations Parameters</td>
<td>29-Nov-08</td>
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<tr>
<td>Second Presentation Delivered</td>
<td>3-Dec-08</td>
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<tr>
<td>Alternative Solutions</td>
<td>5-Dec-08</td>
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<td>Preliminary Budget</td>
<td>5-Dec-08</td>
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<tr>
<td>Hand in PPFS</td>
<td>12-Dec-08</td>
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*Completed on or before date

<table>
<thead>
<tr>
<th>Task</th>
<th>Tentative Dates of Completion</th>
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</thead>
<tbody>
<tr>
<td>Order Chemicals/Seeds for Prototype</td>
<td>Jan-09</td>
</tr>
<tr>
<td>Project Brief with Industrial Consultant</td>
<td>Jan-09</td>
</tr>
<tr>
<td>Unisim Design</td>
<td>Jan-09</td>
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<tr>
<td>Chemical Experiments for Prototype</td>
<td>Feb-09</td>
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<td>Base case</td>
<td>Feb-09</td>
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<td>Piping</td>
<td>Mar-09</td>
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<td>Heat Exchangers</td>
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<td>Compressors</td>
<td>Mar-09</td>
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<tr>
<td>Reactors</td>
<td>Mar-09</td>
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<tr>
<td>Separations Equipment</td>
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<tr>
<td>Biodiesel Plant Design</td>
<td>Apr-09</td>
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<tr>
<td>Complete Prototype</td>
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<td>PFD</td>
<td>Apr-09</td>
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<tr>
<td>Final Report</td>
<td>May-09</td>
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</tbody>
</table>
10. Conclusion
It has been shown that the parameters that govern the feasibility of this project will not hinder it from being completed. A plus for the project is that the team has the opportunity of doing laboratory work and building a prototype to determine missing data. It is projected that this project will be completed within the spring semester, before the end of the school year.
Appendices

A. Bibliography


<http://worldisgreen.files.wordpress.com/2008/03/toil-jatropha-may2007.jpg>

<http://www.thewoodexplorer.com/maindata/Picts/Jatropha1.jpg>


B. Preliminary Process Flow Diagram

Figure B-1. Preliminary Process Flow Diagram
C. Material Safety Data Sheets

Material Safety Data Sheet
Sodium hydroxide, solid, pellets or beads

ACC# 21300

Section 1 - Chemical Product and Company Identification

**MSDS Name:** Sodium hydroxide, solid, pellets or beads  
**Synonyms:** Caustic soda; Soda lye; Sodium hydrate; Lye.

**Company Identification:**  
Fisher Scientific  
1 Reagent Lane  
Fair Lawn, NJ 07410

**For information, call:** 201-796-7100  
**Emergency Number:** 201-796-7100  
**For CHEMTREC assistance, call:** 800-424-9300  
**For International CHEMTREC assistance, call:** 703-527-3887

Section 2 - Composition, Information on Ingredients

<table>
<thead>
<tr>
<th>CAS#</th>
<th>Chemical Name</th>
<th>Percent</th>
<th>EINECS/ELINCS</th>
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<tbody>
<tr>
<td>497-19-8</td>
<td>Sodium carbonate</td>
<td>&lt;3</td>
<td>207-838-8</td>
</tr>
<tr>
<td>1310-73-2</td>
<td>Sodium hydroxide</td>
<td>95-100</td>
<td>215-185-5</td>
</tr>
</tbody>
</table>

**Hazard Symbols:** C  
**Risk Phrases:** 35

Section 3 - Hazards Identification

**EMERGENCY OVERVIEW**

**Target Organs:** Eyes, skin, mucous membranes.

**Potential Health Effects**

**Eye:** Causes eye burns. May cause chemical conjunctivitis and corneal damage.  
**Skin:** Causes skin burns. May cause deep, penetrating ulcers of the skin. May cause skin rash (in milder cases), and cold and clammy skin with cyanosis or pale color.  
**Ingestion:** May cause severe and permanent damage to the digestive tract. Causes
gastrointestinal tract burns. May cause perforation of the digestive tract. Causes severe pain, nausea, vomiting, diarrhea, and shock. May cause corrosion and permanent tissue destruction of the esophagus and digestive tract. May cause systemic effects.

**Inhalation:** Irritation may lead to chemical pneumonitis and pulmonary edema. Causes severe irritation of upper respiratory tract with coughing, burns, breathing difficulty, and possible coma. Causes chemical burns to the respiratory tract.

**Chronic:** Prolonged or repeated skin contact may cause dermatitis. Effects may be delayed.

---

**Section 4 - First Aid Measures**

**Eyes:** In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical aid immediately.

**Skin:** In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Get medical aid immediately. Wash clothing before reuse.

**Ingestion:** If swallowed, do NOT induce vomiting. Get medical aid immediately. If victim is fully conscious, give a cupful of water. Never give anything by mouth to an unconscious person.

**Inhalation:** If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical aid.

**Notes to Physician:** Treat symptomatically and supportively.

---

**Section 5 - Fire Fighting Measures**

**General Information:** As in any fire, wear a self-contained breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent), and full protective gear. Use water spray to keep fire-exposed containers cool. Use water with caution and in flooding amounts. Contact with moisture or water may generate sufficient heat to ignite nearby combustible materials. Contact with metals may evolve flammable hydrogen gas.

**Extinguishing Media:** Substance is noncombustible; use agent most appropriate to extinguish surrounding fire. Do NOT get water inside containers.

---

**Section 6 - Accidental Release Measures**

**General Information:** Use proper personal protective equipment as indicated in Section 8.

**Spills/Leaks:** Vacuum or sweep up material and place into a suitable disposal container. Avoid runoff into storm sewers and ditches which lead to waterways. Clean up spills immediately, observing precautions in the Protective Equipment section. Avoid generating dusty conditions. Provide ventilation. Do not get water on spilled substances or inside containers.

---

**Section 7 - Handling and Storage**

**Handling:** Wash thoroughly after handling. Do not allow water to get into the container because of violent reaction. Minimize dust generation and accumulation. Do not get in eyes,
on skin, or on clothing. Keep container tightly closed. Avoid ingestion and inhalation. Discard contaminated shoes. Use only with adequate ventilation.

**Storage:** Store in a tightly closed container. Store in a cool, dry, well-ventilated area away from incompatible substances. Keep away from metals. Corrosives area. Keep away from acids. Store protected from moisture. Containers must be tightly closed to prevent the conversion of NaOH to sodium carbonate by the CO2 in air.

### Section 8 - Exposure Controls, Personal Protection

**Engineering Controls:** Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower. Use adequate general or local exhaust ventilation to keep airborne concentrations below the permissible exposure limits.

**Exposure Limits**

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>ACGIH</th>
<th>NIOSH</th>
<th>OSHA - Final PELs</th>
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<tbody>
<tr>
<td>Sodium carbonate</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Sodium hydroxide</td>
<td>C 2 mg/m3</td>
<td>10 mg/m3 IDLH</td>
<td>2 mg/m3 TWA</td>
</tr>
</tbody>
</table>

**OSHA Vacated PELs:** Sodium carbonate: No OSHA Vacated PELs are listed for this chemical. Sodium hydroxide: C 2 mg/m3

**Personal Protective Equipment**

**Eyes:** Wear chemical goggles.

**Skin:** Wear appropriate protective gloves to prevent skin exposure.

**Clothing:** Wear appropriate protective clothing to prevent skin exposure.

**Respirators:** A respiratory protection program that meets OSHA's 29 CFR 1910.134 and ANSI Z88.2 requirements or European Standard EN 149 must be followed whenever workplace conditions warrant a respirator's use.

### Section 9 - Physical and Chemical Properties

**Physical State:** Solid

**Appearance:** white

**Odor:** Odorless

**pH:** 14 (5% aq soln)

**Vapor Pressure:** 1 mm Hg @739 deg C

**Vapor Density:** Not available.

**Evaporation Rate:** Not available.

**Viscosity:** Not available.

**Boiling Point:** 1390 deg C @ 760 mm Hg

**Freezing/Melting Point:** 318 deg C

**Autoignition Temperature:** Not applicable.

**Flash Point:** Not applicable.

**Decomposition Temperature:** Not available.

**NFPA Rating:** (estimated) Health: 3; Flammability: 0; Reactivity: 1

**Explosion Limits, Lower:** Not available.

**Upper:** Not available.

**Solubility:** Soluble.

**Specific Gravity/Density:** 2.13 g/cm3
**Section 10 - Stability and Reactivity**

**Chemical Stability:** Stable at room temperature in closed containers under normal storage and handling conditions.

**Conditions to Avoid:** Moisture, contact with water, exposure to moist air or water, prolonged exposure to air.

**Incompatibilities with Other Materials:** Acids, water, flammable liquids, organic halogens, metals, aluminum, zinc, tin, leather, wool, nitromethane.

**Hazardous Decomposition Products:** Toxic fumes of sodium oxide.

**Hazardous Polymerization:** Will not occur.

**Section 11 - Toxicological Information**

**RTECS#:**
- CAS# 497-19-8: VZ4050000
- CAS# 1310-73-2: WB4900000

**LD50/LC50:**
- CAS# 497-19-8:
  - Draize test, rabbit, eye: 100 mg/24H Moderate;
  - Draize test, rabbit, eye: 50 mg Severe;
  - Draize test, rabbit, skin: 500 mg/24H Mild;
  - Inhalation, mouse: LC50 = 1200 mg/m3/2H;
  - Inhalation, rat: LC50 = 2300 mg/m3/2H;
  - Oral, mouse: LD50 = 6600 mg/kg;
  - Oral, rat: LD50 = 4090 mg/kg;
- CAS# 1310-73-2:
  - Draize test, rabbit, eye: 400 ug Mild;
  - Draize test, rabbit, eye: 1% Severe;
  - Draize test, rabbit, eye: 50 ug/24H Severe;
  - Draize test, rabbit, eye: 1 mg/24H Severe;
  - Draize test, rabbit, skin: 500 mg/24H Severe;

**Carcinogenicity:**
- CAS# 497-19-8: Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA.
- CAS# 1310-73-2: Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA.

**Epidemiology:** No information available.

**Teratogenicity:** No information available.

**Reproductive Effects:** No information available.

**Neurotoxicity:** No information available.

**Mutagenicity:** No information available.

**Other Studies:** See actual entry in RTECS for complete information.

**Section 12 - Ecological Information**
Section 13 - Disposal Considerations

Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. US EPA guidelines for the classification determination are listed in 40 CFR Parts 261.3. Additionally, waste generators must consult state and local hazardous waste regulations to ensure complete and accurate classification.

**RCRA P-Series**: None listed.
**RCRA U-Series**: None listed.

Section 14 - Transport Information

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Section 15 - Regulatory Information

**US FEDERAL**

**TSCA**
CAS# 497-19-8 is listed on the TSCA inventory.
CAS# 1310-73-2 is listed on the TSCA inventory.

**Health & Safety Reporting List**
None of the chemicals are on the Health & Safety Reporting List.

**Chemical Test Rules**
None of the chemicals in this product are under a Chemical Test Rule.

**Section 12b**
None of the chemicals are listed under TSCA Section 12b.

**TSCA Significant New Use Rule**
None of the chemicals in this material have a SNUR under TSCA.

**SARA**

**Section 302 (RQ)**
CAS# 1310-73-2: final RQ = 1000 pounds (454 kg)

**Section 302 (TPQ)**
None of the chemicals in this product have a TPQ.

**SARA Codes**

**Section 313**
No chemicals are reportable under Section 313.

**Clean Air Act:**
This material does not contain any hazardous air pollutants. This material does not contain any Class 1 Ozone depleters. This material does not contain any Class 2 Ozone depleters.

**Clean Water Act:**
CAS# 1310-73-2 is listed as a Hazardous Substance under the CWA. None of the chemicals in this product are listed as Priority Pollutants under the CWA. None of the chemicals in this product are listed as Toxic Pollutants under the CWA.

**OSHA:**
None of the chemicals in this product are considered highly hazardous by OSHA.

**STATE**
CAS# 497-19-8 is not present on state lists from CA, PA, MN, MA, FL, or NJ.
CAS# 1310-73-2 can be found on the following state right to know lists: California, New Jersey, Florida, Pennsylvania, Minnesota, Massachusetts.
California No Significant Risk Level: None of the chemicals in this product are listed.

**European/International Regulations**

**European Labeling in Accordance with EC Directives**

**Hazard Symbols:**
C

**Risk Phrases:**
R 35 Causes severe burns.

**Safety Phrases:**
S 26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S 37/39 Wear suitable gloves and eye/face protection.
S 45 In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

**WGK (Water Danger/Protection)**
CAS# 497-19-8: 1
CAS# 1310-73-2: 1

**Canada**
CAS# 497-19-8 is listed on Canada's DSL List. CAS# 497-19-8 is listed on Canada's DSL List. CAS# 1310-73-2 is listed on Canada's DSL List. CAS# 1310-73-2 is listed on Canada's DSL List.

This product has a WHMIS classification of E.
CAS# 497-19-8 is listed on Canada's Ingredient Disclosure List.
CAS# 1310-73-2 is listed on Canada's Ingredient Disclosure List.

**Exposure Limits**
CAS# 1310-73-2: OEL-AUSTRALIA:TWA 2 mg/m3 OEL-BELGIUM:STEL 2 mg/m3
OEL-DENMARK:TWA 2 mg/m3 OEL-FINLAND:TWA 2 mg/m3 OEL-FRANCE:TWA 2 mg/m3
OEL-GERMANY:TWA 2 mg/m3 OEL-JAPAN:STEL 2 mg/m3 OEL-THE NETHERLANDS:TWA 2 mg/m3
OEL-THE PHILIPPINES:TWA 2 mg/m3 OEL-SWEDEN:TWA 2 mg/m3
OEL-SWITZERLAND:TWA 2 mg/m3; STEL 4 mg/m3
OEL-TURKEY:TWA 2 mg/m3 OEL-UNITED KINGDOM:TWA 2 mg/m3; STEL 2 mg/m3
OEL IN BULGARIA, COLOMBIA, JORDAN, KOREA check ACGIH TLV OEL IN NEW ZEALAND, SINGAPORE, VIETNAM check ACGI TLV

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**Section 16 - Additional Information**
MSDS Creation Date: 12/12/1997
Revision #4 Date: 8/01/2001
The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall Fisher be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if Fisher has been advised of the possibility of such damages.
Material Safety Data Sheet
Methyl Alcohol, Reagent ACS, 99.8% (GC)

ACC# 95294

Section 1 - Chemical Product and Company Identification

**MSDS Name:** Methyl Alcohol, Reagent ACS, 99.8% (GC)

**Catalog Numbers:** AC423950000, AC423950010, AC423950020, AC423955000, AC9541632, AC423952

**Synonyms:** Carbinol; Methanol; Methyl hydroxide; Monohydroxymethane; Pyroxylic spirit; Wood alcohol; Wood naptha; Wood spirit; Monohydroxymethane; Methyl hydrate.

**Company Identification:**
Acros Organics N.V.
One Reagent Lane
Fair Lawn, NJ 07410

For information in North America, call: 800-ACROS-01
For emergencies in the US, call CHEMTREC: 800-424-9300

Section 2 - Composition, Information on Ingredients

<table>
<thead>
<tr>
<th>CAS#</th>
<th>Chemical Name</th>
<th>Percent</th>
<th>EINECS/ELINCS</th>
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<tbody>
<tr>
<td>67-56-1</td>
<td>Methyl alcohol</td>
<td>99+</td>
<td>200-659-6</td>
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</table>

**Hazard Symbols:** T F

**Risk Phrases:** 11 23/24/25 39/23/24/25

Section 3 - Hazards Identification

**EMERGENCY OVERVIEW**

Appearance: clear, colorless. Flash Point: 11 deg C. Poison! Cannot be made non-poisonous. Causes eye and skin irritation. May be absorbed through intact skin. This substance has caused adverse reproductive and fetal effects in animals. **Danger! Flammable liquid and vapor.** Harmful if inhaled. May be fatal or cause blindness if swallowed. May cause central nervous system depression. May cause digestive tract irritation with nausea, vomiting, and diarrhea. Causes respiratory tract irritation. May cause liver, kidney and heart damage.

**Target Organs:** Kidneys, heart, central nervous system, liver, eyes.

**Potential Health Effects**

**Eye:** Produces irritation, characterized by a burning sensation, redness, tearing, inflammation, and possible corneal injury. May cause painful sensitization to light.

**Skin:** Causes moderate skin irritation. May be absorbed through the skin in harmful amounts. Prolonged and/or repeated contact may cause defatting of the skin and dermatitis.

**Ingestion:** May be fatal or cause blindness if swallowed. May cause gastrointestinal irritation with nausea, vomiting and diarrhea. May cause systemic toxicity with acidosis. May cause central nervous system depression, characterized by excitement, followed by headache, dizziness, drowsiness, and nausea. Advanced stages may cause collapse,
unconsciousness, coma and possible death due to respiratory failure. May cause cardiopulmonary system effects. 

**Inhalation:** Harmful if inhaled. May cause adverse central nervous system effects including headache, convulsions, and possible death. May cause visual impairment and possible permanent blindness. Causes irritation of the mucous membrane.  

**Chronic:** Prolonged or repeated skin contact may cause dermatitis. Chronic inhalation and ingestion may cause effects similar to those of acute inhalation and ingestion. Chronic exposure may cause reproductive disorders and teratogenic effects. Laboratory experiments have resulted in mutagenic effects. Prolonged exposure may cause liver, kidney, and heart damage.

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**Section 4 - First Aid Measures**

**Eyes:** Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical aid immediately.  

**Skin:** Immediately flush skin with plenty of soap and water for at least 15 minutes while removing contaminated clothing and shoes. Get medical aid if irritation develops or persists. Wash clothing before reuse.  

**Ingestion:** If victim is conscious and alert, give 2-4 cupfuls of milk or water. Never give anything by mouth to an unconscious person. Get medical aid immediately. Induce vomiting by giving one teaspoon of Syrup of Ipecac.  

**Inhalation:** Get medical aid immediately. Remove from exposure to fresh air immediately. If breathing is difficult, give oxygen. Do NOT use mouth-to-mouth resuscitation. If breathing has ceased apply artificial respiration using oxygen and a suitable mechanical device such as a bag and a mask.  

**Notes to Physician:** Effects may be delayed. Ethanol may inhibit methanol metabolism.

---

**Section 5 - Fire Fighting Measures**

**General Information:** Containers can build up pressure if exposed to heat and/or fire. As in any fire, wear a self-contained breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent), and full protective gear. Water runoff can cause environmental damage. Dike and collect water used to fight fire. Vapors can travel to a source of ignition and flash back. During a fire, irritating and highly toxic gases may be generated by thermal decomposition or combustion. Flammable Liquid. Can release vapors that form explosive mixtures at temperatures above the flashpoint. Use water spray to keep fire-exposed containers cool. Water may be ineffective. Material is lighter than water and a fire may be spread by the use of water. Vapors may be heavier than air. They can spread along the ground and collect in low or confined areas. May be ignited by heat, sparks, and flame.  

**Extinguishing Media:** For small fires, use dry chemical, carbon dioxide, water spray or alcohol-resistant foam. Use water spray to cool fire-exposed containers. Water may be ineffective. For large fires, use water spray, fog or alcohol-resistant foam. Do NOT use straight streams of water.

---

**Section 6 - Accidental Release Measures**

**General Information:** Use proper personal protective equipment as indicated in Section 8.
Spills/Leaks: Scoop up with a nonsparking tool, then place into a suitable container for disposal. Use water spray to disperse the gas/vapor. Remove all sources of ignition. Absorb spill using an absorbent, non-combustible material such as earth, sand, or vermiculite. Do not use combustible materials such as saw dust. Provide ventilation. A vapor suppressing foam may be used to reduce vapors. Water spray may reduce vapor but may not prevent ignition in closed spaces.

Section 7 - Handling and Storage

Handling: Wash thoroughly after handling. Remove contaminated clothing and wash before reuse. Ground and bond containers when transferring material. Do not breathe dust, vapor, mist, or gas. Do not get in eyes, on skin, or on clothing. Empty containers retain product residue, (liquid and/or vapor), and can be dangerous. Keep container tightly closed. Avoid contact with heat, sparks and flame. Do not ingest or inhale. Use only in a chemical fume hood. Do not pressurize, cut, weld, braze, solder, drill, grind, or expose empty containers to heat, sparks or open flames.

Storage: Keep away from heat, sparks, and flame. Keep away from sources of ignition. Store in a cool, dry, well-ventilated area away from incompatible substances. Flammables-area. Keep containers tightly closed. Do not store in aluminum or lead containers.

Section 8 - Exposure Controls, Personal Protection

Engineering Controls: Use explosion-proof ventilation equipment. Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower. Use adequate general or local exhaust ventilation to keep airborne concentrations below the permissible exposure limits. Use only under a chemical fume hood.

Exposure Limits

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>ACGIH</th>
<th>NIOSH</th>
<th>OSHA - Final PELs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methyl alcohol</td>
<td>200 ppm TWA; 250 ppm STEL; skin - potential for cutaneous absorption</td>
<td>200 ppm TWA; 260 mg/m3 TWA 6000 ppm IDLH</td>
<td>200 ppm TWA; 260 mg/m3 TWA</td>
</tr>
</tbody>
</table>

OSHA Vacated PELs: Methyl alcohol: 200 ppm TWA; 260 mg/m3 TWA; 250 ppm STEL; 325 mg/m3 STEL

Personal Protective Equipment

Eyes: Wear chemical goggles.
Skin: Wear appropriate protective gloves to prevent skin exposure.
Clothing: Wear appropriate protective clothing to prevent skin exposure.
Respirators: A respiratory protection program that meets OSHA's 29 CFR 1910.134 and ANSI Z88.2 requirements or European Standard EN 149 must be followed whenever workplace conditions warrant a respirator’s use.

Section 9 - Physical and Chemical Properties

Physical State: Liquid
Appearance: clear, colorless
Odor: alcohol-like - weak odor
Section 10 - Stability and Reactivity

**Chemical Stability:** Stable under normal temperatures and pressures.

**Conditions to Avoid:** High temperatures, incompatible materials, ignition sources, oxidizers.

**Incompatibilities with Other Materials:** Acids (mineral, non-oxidizing, e.g. hydrochloric acid, hydrofluoric acid, muriatic acid, phosphoric acid), acids (mineral, oxidizing, e.g. chromic acid, hypochlorous acid, nitric acid, sulfuric acid), acids (organic, e.g. acetic acid, benzoic acid, formic acid, methanoic acid, oxalic acid), azo, diazo, and hydrazines (e.g. dimethyl hydrazine, hydrazine, methyl hydrazine), isocyanates (e.g. methyl isocyanate), nitrides (e.g. potassium nitride, sodium nitride), peroxides and hydroperoxides (organic, e.g. acetyl peroxide, benzoyl peroxide, butyl peroxide, methyl ethyl ketone peroxide), epoxides (e.g. butyl glycidyl ether), Oxidants (such as barium perchlorate, bromine, chlorine, hydrogen peroxide, lead perchlorate, perchloric acid, sodium hypochlorite)., Active metals (such as potassium and magnesium)., acetyl bromide, alkyl aluminum salts, beryllium dihydride, carbontetrachloride, carbon tetrachloride + metals, chloroform + heat, chloroform + sodium hydroxide, cyanuric chloride, diethyl zinc, nitric acid, potassium-tert-butoxide, chloroform + hydroxide, water reactive substances (e.g. acetic anyhdride, alkyl aluminum chloride, calcium carbide, ethyl dichlorosilane).

**Hazardous Decomposition Products:** Carbon monoxide, irritating and toxic fumes and gases, carbon dioxide, formaldehyde.

**Hazardous Polymerization:** Will not occur.

Section 11 - Toxicological Information

**RTECS#:**
**CAS# 67-56-1:** PC1400000

**LD50/LC50:**
**CAS# 67-56-1:**
Draize test, rabbit, eye: 40 mg Moderate;
Draize test, rabbit, eye: 100 mg/24H Moderate;
Draize test, rabbit, skin: 20 mg/24H Moderate;
Inhalation, rat: LC50 = 64000 ppm/4H; Oral, mouse: LD50 = 7300 mg/kg; Oral, rabbit: LD50 = 14200 mg/kg; Oral, rat: LD50 = 5628 mg/kg; Skin, rabbit: LD50 = 15800 mg/kg;

**Carcinogenicity:**
CAS# 67-56-1: Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA.

**Epidemiology:** Methanol has been shown to produce fetotoxicity in the embryo or fetus of laboratory animals. Specific developmental abnormalities include cardiovascular, musculoskeletal, and urogenital systems.

**Teratogenicity:** Effects on Newborn: Behaviorial, Oral, rat: TDLo=7500 mg/kg (female 17-19 days after conception). Effects on Embryo or Fetus: Fetotoxicity, Inhalation, rat: TCLo=10000 ppm/7H (female 7-15 days after conception). Specific Developmental Abnormalities: Cardiovascular, Musculoskeletal, Urogenital, Inhalation, rat: TCLo=20000 ppm/7H (7-14 days after conception).

**Reproductive Effects:** Paternal Effects: Spermatogenesis: Intraperitoneal, mouse TDLo=5 g/kg (male 5 days pre-mating). Fertility: Oral, rat: TDLo = 35295 mg/kg (female 1-15 days after conception). Paternal Effects: Testes, Epididymis, Sperm duct: Oral, rat: TDLo = 200 ppm/20H (male 78 weeks pre-mating).

**Neurotoxicity:** No information available.

**Mutagenicity:** DNA inhibition: Human Lymphocyte = 300 mmol/L. DNA damage: Oral, rat = 10 umol/kg. Mutation in microorganisms: Mouse Lymphocyte = 7900 mg/L. Cytogenetic analysis: Oral, mouse = 1 gm/kg.

**Other Studies:** Standard Draize Test(Skin, rabbit) = 20 mg/24H (Moderate) Standard Draize Test: Administration into the eye (rabbit) = 40 mg (Moderate). Standard Draize test: Administration into the eye (rabbit) = 100 mg/24H (Moderate).

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### Section 12 - Ecological Information

**Ecotoxicity:** Fish: Fathead Minnow: 29.4 g/L; 96 Hr; LC50 (unspecified) Goldfish: 250 ppm; 11 Hr; resulted in death Rainbow trout: 8000 mg/L; 48 Hr; LC50 (unspecified) Rainbow trout: LC50 = 13-68 mg/L; 96 Hr.; 12 degrees C Fathead Minnow: LC50 = 29400 mg/L; 96 Hr.; 25 degrees C, pH 7.63 Rainbow trout: LC50 = 8000 mg/L; 48 Hr.; Unspecified ria: Phytobacterium phosphoreum: EC50 = 51,000-320,000 mg/L; 30 minutes; Microtox test No data available.

**Environmental:** Dangerous to aquatic life in high concentrations. Aquatic toxicity rating: TLM 96>1000 ppm. May be dangerous if it enters water intakes. Methyl alcohol is expected to biodegrade in soil and water very rapidly. This product will show high soil mobility and will be degraded from the ambient atmosphere by the reaction with photochemically produced hyroxyl radicals with an estimated half-life of 17.8 days. Bioconcentration factor for fish (golden ide) < 10. Based on a log Kow of -0.77, the BCF value for methanol can be estimated to be 0.2.

**Physical:** No information available.

**Other:** None.

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### Section 13 - Disposal Considerations

Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. US EPA guidelines for the classification determination are listed in 40 CFR Parts 261.3. Additionally, waste generators must consult state and local hazardous waste...
regulations to ensure complete and accurate classification.  
RCRA P-Series: None listed.  

Section 14 - Transport Information

<table>
<thead>
<tr>
<th>Shipping Name</th>
<th>US DOT</th>
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<td>Additional Info</td>
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<td>Flashpoint 11 C</td>
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</tbody>
</table>

Section 15 - Regulatory Information

US FEDERAL

TSCA  
CAS# 67-56-1 is listed on the TSCA inventory.

Health & Safety Reporting List  
None of the chemicals are on the Health & Safety Reporting List.

Chemical Test Rules  
None of the chemicals in this product are under a Chemical Test Rule.

Section 12b  
None of the chemicals are listed under TSCA Section 12b.

TSCA Significant New Use Rule  
None of the chemicals in this material have a SNUR under TSCA.

SARA  
Section 302 (RQ)  
CAS# 67-56-1: final RQ = 5000 pounds (2270 kg)

Section 302 (TPQ)  
None of the chemicals in this product have a TPQ.

SARA Codes  
CAS # 67-56-1: acute, flammable.

Section 313  
This material contains Methyl alcohol (CAS# 67-56-1, 99%), which is subject to the reporting requirements of Section 313 of SARA Title III and 40 CFR Part 373.

Clean Air Act:  
CAS# 67-56-1 is listed as a hazardous air pollutant (HAP). This material does not contain any Class 1 Ozone depletors. This material does not contain any Class 2 Ozone depletors.

Clean Water Act:  
None of the chemicals in this product are listed as Hazardous Substances under the CWA. None of the chemicals in this product are listed as Priority Pollutants under the CWA. None of the chemicals in this product are listed as Toxic Pollutants under the CWA.

OSHA:  
None of the chemicals in this product are considered highly hazardous by OSHA.
STATE
CAS# 67-56-1 can be found on the following state right to know lists: California, New Jersey, Florida, Pennsylvania, Minnesota, Massachusetts.
California No Significant Risk Level: None of the chemicals in this product are listed.

European/International Regulations
European Labeling in Accordance with EC Directives
Hazard Symbols:
T F
Risk Phrases:
R 11 Highly flammable.
R 23/24/25 Toxic by inhalation, in contact with skin and if swallowed.
R 39/23/24/25 Toxic: danger of very serious irreversible effects through inhalation, in contact with skin and if swallowed.

Safety Phrases:
S 16 Keep away from sources of ignition - No smoking.
S 36/37 Wear suitable protective clothing and gloves.
S 45 In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
S 7 Keep container tightly closed.

WGK (Water Danger/Protection)
CAS# 67-56-1: 1

Canada
CAS# 67-56-1 is listed on Canada's DSL List. CAS# 67-56-1 is listed on Canada's DSL List. This product has a WHMIS classification of B2, D1A, D2B.
CAS# 67-56-1 is listed on Canada's Ingredient Disclosure List.

Exposure Limits
CAS# 67-56-1: OEL-ARAB Republic of Egypt: TWA 200 ppm (260 mg/m3); Skin OEL-AUSTRALIA: TWA 200 ppm (260 mg/m3); STEL 250 ppm; Skin OEL-BELGIUM: TWA 200 ppm (262 mg/m3); STEL 250 ppm; Skin OEL-CZECHOSLOVAKIA: TWA 100 mg/m3; STEL 500 mg/m3; Skin OEL-DENMARK: TWA 200 ppm (260 mg/m3); Skin OEL-FINLAND: TWA 200 ppm (260 mg/m3); STEL 250 ppm; Skin OEL-FRANCE: TWA 200 ppm (260 mg/m3); STEL 1000 ppm (1300 mg/m3) OEL-GERMANY: TWA 200 ppm (260 mg/m3); STEL 100 mg/m3; Skin OEL-HUNGARY: TWA 50 mg/m3; STEL 100 mg/m3; Skin JAN9 OEL-JAPAN: TWA 200 ppm (260 mg/m3); Skin OEL-THE NETHERLANDS: TWA 200 ppm (260 mg/m3); Skin OEL-THE PHILIPPINES: TWA 200 ppm (260 mg/m3) OEL-POLAND: TWA 100 mg/m3; OEL-RUSSIA: TWA 200 ppm; STEL 5 mg/m3; Skin OEL-SWEDEN: TWA 200 ppm (250 mg/m3); STEL 250 ppm (350 mg/m3); Skin OEL-SWITZERLAND: TWA 200 ppm (260 mg/m3); STEL 400 ppm; Skin OEL-THAILAND: TWA 200 ppm (260 mg/m3); OEL-TURKEY: TWA 200 ppm (260 mg/m3); OEL-UNITED KINGDOM: TWA 200 ppm (260 mg/m3); STEL 250 ppm; Skin OEL IN BULGARIA, COLOMBIA, JORDAN, KOREA check ACGIH TLV OEL IN NEW ZEALAND, SINGAPORE, VIETNAM check ACGIH TLV

Section 16 - Additional Information
MSDS Creation Date: 7/21/1999
Revision #4 Date: 3/14/2001
The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall Fisher be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if Fisher has been advised of the possibility of such damages.
Material Safety Data Sheet
Hexane (certified ACS grade)

ACC# 10951

Section 1 - Chemical Product and Company Identification

**MSDS Name:** Hexane (certified ACS grade)
**Synonyms:** n-Hexane; Hexyl hydride; Dipropyl; normal-Hexane; Hex.
**Company Identification:**
Fisher Scientific
1 Reagent Lane
Fair Lawn, NJ 07410
**For information, call:** 201-796-7100
**Emergency Number:** 201-796-7100
**For CHEMTREC assistance, call:** 800-424-9300
**For International CHEMTREC assistance, call:** 703-527-3887

Section 2 - Composition, Information on Ingredients

<table>
<thead>
<tr>
<th>CAS#</th>
<th>Chemical Name</th>
<th>Percent</th>
<th>EINECS/ELINCS</th>
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</thead>
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<tr>
<td>0-01-1</td>
<td>Various Methylpentanes</td>
<td>4.2</td>
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<tr>
<td>96-37-7</td>
<td>Methylcyclopentane</td>
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<td>202-503-2</td>
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<tr>
<td>110-54-3</td>
<td>Hexane</td>
<td>86.1</td>
<td>203-777-6</td>
</tr>
</tbody>
</table>

**Hazard Symbols:** XN F N
**Risk Phrases:** 11 38 48/20 62 51/53 65 67

Section 3 - Hazards Identification

**EMERGENCY OVERVIEW**

**Target Organs:** Central nervous system, respiratory system, eyes, skin, peripheral nervous system.

**Potential Health Effects**
**Eye:** Causes mild eye irritation. Causes redness and pain. May cause blurred vision, tearing,
and conjunctivitis.

**Skin:** Prolonged and/or repeated contact may cause defatting of the skin and dermatitis. Causes irritation with burning pain, itching, and redness. Absorbed through the skin.

**Ingestion:** Aspiration hazard. May cause gastrointestinal irritation with nausea, vomiting and diarrhea. Aspiration of material into the lungs may cause chemical pneumonitis, which may be fatal. May cause central nervous system effects. Aspiration can cause asphyxia, brain damage, and cardiac arrest.

**Inhalation:** Causes respiratory tract irritation. Exposure produces central nervous system depression. Aspiration may cause respiratory swelling and pneumonitis. Inhalation of high concentrations may cause narcotic effects. Vapors may cause dizziness or suffocation. Exposure may cause vertigo, hallucinations, fatigue, muscle weakness, visual disturbances, nervous system disturbances, coughing, chest pains, difficulty in breathing, lung irritation, gastrointestinal disturbances, and edema which may be fatal.

**Chronic:** Prolonged or repeated skin contact may cause defatting and dermatitis. Prolonged or repeated exposure may cause adverse reproductive effects. May cause fetal effects. Chronic exposure may cause visual disturbances. Laboratory experiments have resulted in mutagenic effects. Peripheral neuropathy symptoms include: muscular weakness, paresthesia, numbing of the hands, feet, legs and arms, unsteadiness, and difficulty in walking and standing. Repeated exposure may cause nervous system abnormalities with muscle weakness and damage, motor incoordination, and sensation disturbances. Chronic exposure produces peripheral neuropathy.

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### Section 4 - First Aid Measures

**Eyes:** In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical aid.

**Skin:** In case of contact, flush skin with plenty of water. Remove contaminated clothing and shoes. Get medical aid if irritation develops and persists. Wash clothing before reuse.

**Ingestion:** Potential for aspiration if swallowed. Get medical aid immediately. Do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person.

**Inhalation:** If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical aid.

**Notes to Physician:** Treat symptomatically and supportively. For ingestion, the stomach should be intubated, aspirated, and lavaged with a slurry of activated charcoal--protect the airway from aspiration of gastric contents. Monitor arterial blood gases in cases of severe aspiration.

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### Section 5 - Fire Fighting Measures

**General Information:** As in any fire, wear a self-contained breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent), and full protective gear. Vapors may form an explosive mixture with air. During a fire, irritating and highly toxic gases may be generated by thermal decomposition or combustion. Use water spray to keep fire-exposed containers cool. Extremely flammable liquid and vapor. Water may be ineffective. Material is lighter than water and a fire may be spread by the use of water. May accumulate static electrical charges, and may cause ignition of its own vapors. Containers may explode if exposed to fire. Vapors are heavier than air and may travel to a source of ignition and
flash back. Vapors can spread along the ground and collect in low or confined areas. **Extinguishing Media:** For small fires, use dry chemical, carbon dioxide, water spray or alcohol-resistant foam. Water may be ineffective. Water may spread fire. If water is the only media available, use in flooding amounts. For large fires, use water spray, fog or alcohol-resistant foam. Do NOT use straight streams of water. Contact professional fire-fighters immediately. Cool containers with flooding quantities of water until well after fire is out.

### Section 6 - Accidental Release Measures

**General Information:** Use proper personal protective equipment as indicated in Section 8. **Spills/Leaks:** Absorb spill with inert material (e.g. vermiculite, sand or earth), then place in suitable container. Avoid runoff into storm sewers and ditches which lead to waterways. Clean up spills immediately, observing precautions in the Protective Equipment section. Remove all sources of ignition. Provide ventilation. A vapor suppressing foam may be used to reduce vapors. Use only non-sparking tools and equipment.

### Section 7 - Handling and Storage

**Handling:** Wash thoroughly after handling. Remove contaminated clothing and wash before reuse. Ground and bond containers when transferring material. Avoid contact with eyes, skin, and clothing. Empty containers retain product residue, (liquid and/or vapor), and can be dangerous. Take precautionary measures against static discharges. Avoid contact with heat, sparks and flame. Do not pressurize, cut, weld, braze, solder, drill, grind, or expose empty containers to heat, sparks or open flames. Use only with adequate ventilation. Avoid breathing vapor or mist. **Storage:** Keep away from heat and flame. Keep away from sources of ignition. Store in a tightly closed container. Keep from contact with oxidizing materials. Store in a cool, dry, well-ventilated area away from incompatible substances. Flammables-area.

### Section 8 - Exposure Controls, Personal Protection

**Engineering Controls:** Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower. Use adequate general or local explosion-proof ventilation to keep airborne levels to acceptable levels. **Exposure Limits**

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>ACGIH</th>
<th>NIOSH</th>
<th>OSHA - Final PELs</th>
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<tr>
<td>Various Methylpentanes</td>
<td>none listed</td>
<td>none listed</td>
<td>none listed</td>
</tr>
<tr>
<td>Methylcyclopentane</td>
<td>none listed</td>
<td>none listed</td>
<td>none listed</td>
</tr>
<tr>
<td>Hexane</td>
<td>50 ppm TWA; skin - potential for cutaneous absorption</td>
<td>50 ppm TWA; 180 mg/m³ TWA 1100 ppm IDLH (10 percent lower explosive limit)</td>
<td>500 ppm TWA; 1800 mg/m³ TWA</td>
</tr>
</tbody>
</table>

**OSHA Vacated PELs:** Various Methylpentanes: No OSHA Vacated PELs are listed for this chemical. Methylcyclopentane: No OSHA Vacated PELs are listed for this chemical. Hexane: 50 ppm TWA; 180 mg/m³ TWA

**Personal Protective Equipment**
**Eyes:** Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in 29 CFR 1910.133 or European Standard EN166.

**Skin:** Wear appropriate protective gloves to prevent skin exposure.

**Clothing:** Wear appropriate protective clothing to prevent skin exposure.

**Respirators:** A respiratory protection program that meets OSHA's 29 CFR 1910.134 and ANSI Z88.2 requirements or European Standard EN 149 must be followed whenever workplace conditions warrant a respirator's use.

### Section 9 - Physical and Chemical Properties

**Physical State:** Liquid  
**Appearance:** clear colorless  
**Odor:** gasoline-like  
**pH:** Not available.  
**Vapor Pressure:** 151 mm Hg @ 25 deg C  
**Vapor Density:** 2.97(Air = 1)  
**Evaporation Rate:** Not available.  
**Viscosity:** 0.31 mPas 20 C  
**Boiling Point:** 69 deg C @ 760 mmHg  
**Freezing/Melting Point:** -95 deg C  
**Autoignition Temperature:** 225 deg C (437.00 deg F)  
**Flash Point:** -22 deg C (-7.60 deg F)  
**Decomposition Temperature:** Not available.  
**NFPA Rating:** (estimated) Health: 1; Flammability: 3; Reactivity: 0  
**Explosion Limits, Lower:** 1.1 vol %  
**Upper:** 7.5 vol %  
**Solubility:** Insoluble.  
**Specific Gravity/Density:** 0.6600  
**Molecular Formula:** C6H14  
**Molecular Weight:** 86.18

### Section 10 - Stability and Reactivity

**Chemical Stability:** Stable under normal temperatures and pressures.  
**Conditions to Avoid:** Ignition sources, excess heat, electrical sparks.  
**Incompatibilities with Other Materials:** Strong oxidizing agents, dinitrogen tetraoxide.  
**Hazardous Decomposition Products:** Carbon monoxide, irritating and toxic fumes and gases, carbon dioxide.  
**Hazardous Polymerization:** Will not occur.

### Section 11 - Toxicological Information

**RTECS#:**  
**CAS#** 0-01-1 unlisted.  
**CAS#** 96-37-7: GY4640000  
**CAS#** 110-54-3: MN9275000

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**LD50/LC50:**
Not available.

CAS# 110-54-3:
Draize test, rabbit, eye: 10 mg Mild;
Inhalation, rat: LC50 = 48000 ppm/4H;
Oral, rat: LD50 = 25 gm/kg;

**Carcinogenicity:**
CAS# 0-01-1: Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA. CAS# 96-37-7: Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA. CAS# 110-54-3: Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA.

**Epidemiology:** No data available.

**Teratogenicity:** Effects on Newborn - behavioral: Inhalation, rat: TCLo = 10000 ppm/7H (female 15 days pre-mating and female 1-18 days after conception).; Effects on Embryo or Fetus - fetotoxicity: Inhalation, rat: TCLo = 5000 ppm/20 H (female 6-19 days after conception).

**Reproductive Effects:** No data available.

**Neurotoxicity:** No data available.

**Mutagenicity:** Sex Chromosome Loss and Nondisjunction: Saccharomyces cerevisiae = 132 mmol/L.; Cytogenetic Analysis: Hamster fibroblast = 500 mg/L.

**Other Studies:** No data available.

### Section 12 - Ecological Information

**Ecotoxicity:** No data available. Estimated BCF values = 2.24 and 2.89. These values suggest that hexane will show low bioconcentration in aquatic organisms. Estimated Koc value = 4.11. This product will show slight soil mobility and is expected to rapidly volatilize from moist surface soils.

**Environmental:** Terrestrial: Volatilization and adsorption are expected to be the most important fate processes. Aquatic: Photolysis or hydrolysis are not expected to be important. Atmospheric: Expected to exist entirely in the vapor phase in ambient air, expected half life 2.8 days. Expected to biodegrade but not bioconcentrate.

**Physical:** No information available.

**Other:** No information available.

### Section 13 - Disposal Considerations

Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. US EPA guidelines for the classification determination are listed in 40 CFR Parts 261.3. Additionally, waste generators must consult state and local hazardous waste regulations to ensure complete and accurate classification.

**RCRA P-Series:** None listed.

**RCRA U-Series:** None listed.

### Section 14 - Transport Information

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<th>IATA</th>
<th>RID/ADR</th>
<th>IMO</th>
<th>Canada</th>
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Section 15 - Regulatory Information

US FEDERAL

TSCA
CAS# 0-01-1 is not listed on the TSCA inventory. It is for research and development use only.
CAS# 96-37-7 is listed on the TSCA inventory.
CAS# 110-54-3 is listed on the TSCA inventory.

Health & Safety Reporting List
CAS# 96-37-7: Effective Date: June 20, 1985; Sunset Date: November 9, 1993

Chemical Test Rules
None of the chemicals in this product are under a Chemical Test Rule.

Section 12b
CAS# 96-37-7: 4/12b CAS# 110-54-3: 4/12B/12b

TSCA Significant New Use Rule
None of the chemicals in this material have a SNUR under TSCA.

SARA

Section 302 (RQ)
CAS# 110-54-3: final RQ = 5000 pounds (2270 kg)

Section 302 (TPQ)
None of the chemicals in this product have a TPQ.

SARA Codes
CAS# 96-37-7: flammable. CAS# 110-54-3: acute, chronic, flammable.

Section 313
This material contains Hexane (CAS# 110-54-3, 86.1%), which is subject to the reporting requirements of Section 313 of SARA Title III and 40 CFR Part 373.

Clean Air Act:
CAS# 110-54-3 is listed as a hazardous air pollutant (HAP). This material does not contain any Class 1 Ozone depletors. This material does not contain any Class 2 Ozone depletors.

Clean Water Act:
None of the chemicals in this product are listed as Hazardous Substances under the CWA. None of the chemicals in this product are listed as Priority Pollutants under the CWA. None of the chemicals in this product are listed as Toxic Pollutants under the CWA.

OSHA:
None of the chemicals in this product are considered highly hazardous by OSHA.

STATE
CAS# 0-01-1 is not present on state lists from CA, PA, MN, MA, FL, or NJ.
CAS# 96-37-7 can be found on the following state right to know lists: New Jersey, Florida, Pennsylvania, Massachusetts.
CAS# 110-54-3 can be found on the following state right to know lists: New Jersey, Florida,
Pennsylvania, Minnesota, Massachusetts. California No Significant Risk Level: None of the chemicals in this product are listed.

**European/International Regulations**

**European Labeling in Accordance with EC Directives**

**Hazard Symbols:**

XN F N

**Risk Phrases:**

R 11 Highly flammable.
R 38 Irritating to skin.
R 48/20 Harmful: danger of serious damage to health by prolonged exposure through inhalation.
R 62 Possible risk of impaired fertility.
R 51/53 Toxic to aquatic organisms; may cause long-term adverse effects in the aquatic environment.
R 65 Harmful: may cause lung damage if swallowed.
R 67 Vapors may cause drowsiness and dizziness.

**Safety Phrases:**

S 16 Keep away from sources of ignition - No smoking.
S 29 Do not empty into drains.
S 33 Take precautionary measures against static discharges.
S 36/37 Wear suitable protective clothing and gloves.
S 9 Keep container in a well-ventilated place.
S 61 Avoid release to the environment. Refer to special instructions/Safety data sheets.
S 62 If swallowed, do not induce vomiting: seek medical advice immediately and show this container or label.

**WGK (Water Danger/Protection)**

CAS# 0-01-1: No information available.
CAS# 96-37-7: 1
CAS# 110-54-3: 1

**Canada**

CAS# 96-37-7 is listed on Canada's DSL List. CAS# 96-37-7 is listed on Canada's DSL List. CAS# 110-54-3 is listed on Canada's DSL List. CAS# 110-54-3 is listed on Canada's DSL List.

This product has a WHMIS classification of B2, D2A.

CAS# 0-01-1 is not listed on Canada's Ingredient Disclosure List.
CAS# 96-37-7 is not listed on Canada's Ingredient Disclosure List.
CAS# 110-54-3 is listed on Canada's Ingredient Disclosure List.

**Exposure Limits**

CAS# 110-54-3: OEL-AUSTRALIA:TWA 50 ppm (180 mg/m3) OEL-BELGIUM:TWA 50 ppm (176 mg/m3) OEL-DENMARK:TWA 50 ppm (180 mg/m3) OEL-FINLAND:TWA 50 ppm (180 mg/m3); STEL 150 ppm (530 mg/m3) OEL-FRANCE:TWA 50 ppm (170 mg/m3) OEL-GERMANY:TWA 50 ppm (180 mg/m3) OEL-HUNGARY:TWA 100 mg/m3; STEL 200 mg/m3; Skin OEL-JAPAN:TWA 40 ppm (140 mg/m3); Skin OEL-T
HE NETHERLANDS:TWA 100 ppm (360 mg/m3) OEL-THE PHILIPPINES:TWA 500 ppm (1800 mg/m3) JAN9 OEL-POLAND:TWA 400 mg/m3 OEL-RUSSIA:TWA 40 ppm; STEL 300 mg/m3 OEL-SWEDEN:TWA 25 ppm (90 mg/m3); STEL 50 ppm (180 mg/m3) OEL-SWITZERLAND:TWA 50 ppm (180 mg/m3); STEL 100 ppm (360 mg/m3) OEL-TURKEY:TWA 500 ppm (1800 mg/m3) OEL-UNITED KINGDOM:TWA 100 ppm (360 mg/m3); STEL 125 ppm OEL IN BULGARIA, COLOMBIA, JORDAN, KOREA check ACGIH TLV OEL IN NEW ZEALAND, SINGAPORE, VIETNAM check ACGIH TLV

Section 16 - Additional Information

**MSDS Creation Date:** 6/03/1999  
**Revision #5 Date:** 11/13/2001

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall Fisher be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if Fisher has been advised of the possibility of such damages.