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STUDY ON THE EMULSION STABILITY OF A VEGETABLE OIL WITH DIFFERENT SURFACTANTS

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Abstract
Cutting fluids are very important for the manufacturing industry. Cutting fluids are formulated from mineral oils and are carcinogenic in nature. They have negative impact on health of worker and on the environment. Owing to the problems posed by these cutting fluids, a need has been felt for using cutting fluids which are environment friendly and have no toxic effect on the environment. For this proper oil selection and surfactant selection is important. In order to solve this problem a vegetable oil has been selected and in order to make it completely soluble in water it has been tested with different surfactants.

Keywords: *Emulsion, vegetable, surfactant, environment, disposal*

1. Introduction

Cutting fluids have been used for a long time in the manufacturing sector(Lawal et al., 2012). Cutting fluids are a category of metalworking fluids which are used in metal removal operation(Sluhan, n.d, 2008.). There are different operations which require different type of cutting fluid("Gauthier - 2003 - Metalworking Fluids Oil Mist and Beyond.pdf," n.d.). The function of cutting fluid is to reduce the amount of heat generated in machining and also to provide lubricity. Cutting fluids help in carrying the chips away from the workpiece(El Baradie, 1996a). If the heat generation is not controlled it can affect the cutting tool life significantly. High temperatures are also detrimental to the machining quality and can hamper the productivity. It is thus essential to control the temperature rise during machining for a smooth production.

Oils are generally derived from animals and plants. These have been used as a source of lubricant in the industry for a long time. But with the advent of complex machining operations the industry shifted to using cutting fluids made from mineral oil and petroleum products(Nagendramma and Kaul, 2012). Cutting fluids are formulated from mineral oils by mixing with certain performance enhancing additives and shelf life improvers(Brinksmeier et al., 2015; Byers, 2017; Kajdas, 1989; Schulz et al., 2013). Since oil is insoluble in water because of polarity difference, it has to be mixed with some agents like emulsifiers and surfactants(Shashidhara and Jayaram, 2013, 2010). Surfactants are surface active agents which help in making the oil soluble in water(Binks, 2002).

The conventionally used cutting fluid in the manufacturing industry is highly toxic and causes many problems to the human and to the environment. Cutting fluid causes diseases of skin, respiratory disorders and even cancer. In a study it was found that the cutting fluid caused cancer in mice (Bennett, 1983; Goh and Gan, 1994; Grattan et al., 1989). Dermal diseases are very commonly seen in workers exposed to these cutting fluids. In another study it was found that cutting fluid caused change in the DNA of aquatic plant (Kipling, 1977).

The disposal of cutting fluids is not easy. There are strict regulations for proper disposal of cutting fluids. Cutting fluids have to be neutralized properly before disposal (El Baradie, 1996b). Disposing cutting fluids without proper neutralization can cause negative impact on the aquatic life. It is hence necessary to adopt certain measures to limit the amount of pollution caused due to the disposal of cutting fluids

Due to these problems posed by the cutting fluids there is a need for developing an alternative which can replace these mineral oil based cutting fluids.The solution is a product derived from nature. Vegetable oils have good lubricity and they have a huge potential to be used as cutting fluids. However their formulation needs to be done properly. Due to the different structure of vegetable oils and mineral oils a different method needs to be followed for proper formulation of cutting fluids.

Emulsion stability is important aspect in cutting fluid formulation. The cutting fluid should have reasonable stability so that they can be used for a long period of time. It is seen from literature that very less work is reported on the aspect of emulsion stability. Emulsion stability ensures that a homogenous solution of cutting fluid will be delivered every time the cutting fluid is used.

In this study we have taken non edible Neem oil as base oil for formulating the cutting fluid. In the published literature it is found that most research has been done on edible oils such as coconut oil, palm oil, sunflower oil, groundnut oil. However since these are edible oils, it is not justifiable to use these as industrial product. In practice, ethoxylates of fatty acid esters are found to be better surface-active agents for oil in water emulsions. The solution is to use non edible oils.

In this paper we have used non edible Neem oil and also taken food grade surfactants. Many formulations were tested and their emulsion stability is reported.

2. Material and Methodology

For preparing stable oil in water emulsion non ionic surfactants were selected. Non ionic surfactants are not affected easily. The surfactants selected were coded as T8 and S8.

First the samples were prepared by using surfactants individually by changing the concentration of surfactant and oil. Each surfactant was varied as 5% v/v, 10%, 15% and 20%. The maximum limit was kept 20% to limit the maximum amount of surfactant used.

Each sample comprised 50 ml of concentrate (oil and surfactant). The mixture was mixed thoroughly in a magnetic stirrer at 600 rpm for 10 minutes. The proper procedure is to add surfactant drop by drop in order to get a homogenous solution. After 10 minutes stop the magnetic stirrer carefully take 4 ml of concentrate and transfer it to a test tube. Then add 36 ml of water and shake the mixture vigorously and let it sit stable for observation. Transfer the remaining concentrate into separate test tube in order to see the storage stability of undiluted formulation.

After it was found that stable emulsion is not formed, blend of surfactants were used in different ratio. The highest stability was observed with the blend no 12. Each blend was prepared using magnetic stirrer and the volume of blend was 50 ml. In each test tube the quantity of surfactant is kept 10% v/v and the resulting concentrate is given 100 shakes and then diluted with water to 10% dilution

3. Results and discussion

The samples were coded by the volume of Neem oil (N), volume and surfactant type (T80 for Tween 80 and S80 for Span 80) and the numeric digits representing the quantity in ml, and dilution level (D). Storage stability of concentrate and the emulsion was observed.

Table 1: Experimental results with different surfactants

Sample	code	Observation after 4 week	Result
1	N47.5T80-2.5	1. Initially stable mixture 2. No colour change observed 3. No separation observed 4. No precipitate observed	Stable

2	N45T80-5	1. Initially stable mixture 2. No colour change observed 3. No separation observed 4. No precipitate observed	Stable
3	N42.5T80-7.5	1. Initially stable mixture 2. No colour change observed 3. No separation observed 4. No precipitate observed	Stable
4	N40T80-10	1. Initially stable mixture 2. No colour change observed 3. No separation observed 4. No precipitate observed	Stable
5	N47.5S80-2.5	1. Initially stable mixture 2. No colour change observed 3. No separation observed 4. No precipitate observed	Stable
6	N45S80-5	1. Initially stable mixture 2. No colour change observed 3. No separation observed 4. No precipitate observed	Stable
7	N42.5S80-7.5	1. Initially stable mixture 2. No colour change observed 3. No separation observed 4. No precipitate observed	Stable
8	N40S80-10	1. Initially stable mixture 2. No colour change observed 3. No separation observed 4. No precipitate observed	Stable
9	N47.5T80-2.5-D10	1. 3 distinct layers 2. Top layer visible oil layer thickness 2 mm 3. Middle layer creaming thickness 16 mm 4. Third layer translucent. Thickness 85 mm	Unstable
10	N45T80-5-D10	1. 2 distinct layers with few drops of oil on top 2. Thickness of top layer 18 mm 3. Thickness of bottom translucent layer 85 mm	Unstable
11	N42.5T80-7.5-D10	1. 2 distinct layers with no oil separation 2. Creaming in top layer, thickness of top layer 20 mm 3. Thickness of bottom translucent layer 90 mm	Unstable
12	N40T80-10-D10	1. 2 distinct layers with no oil separation 2. Creaming in top layer, thickness of top layer 15 mm 3. Thickness of bottom translucent layer 95 mm	Unstable
13	N47.5S80-2.5-D10	1. 2 distinct layers visible 2. Top layer dirty yellow with oil drops, thickness 15 mm 3. Bottom layer translucent, thickness 95 mm	Unstable

14	N45S80-5-D10	1. 4 distinct layers visible 2. Top 1st layer dirty yellow with streak of white layer, thickness 2 mm 3. 2nd layer oil, thickness 7mm 4. 3rd layer greyish and silver, thickness 1mm 5. Bottom 4th layer translucent, thickness 105 mm	Unstable
15	N42.5S80-7.5-D10	1. 3 distinct layers visible 2. Top 1st layer dirty yellow with oil, thickness 8 mm 3. 2nd layer silver, thickness 2 mm 4. Bottom 3rd layer translucent, thickness 95 mm	Unstable
16	N40S80-10-D10	1. 3 distinct layers visible 2. Top 1st layer dirty yellow with oil, thickness 10 mm 3. 2nd layer streak of silver colour, thickness 2 mm 4. Bottom 3rd layer translucent, thickness 90 mm	Unstable

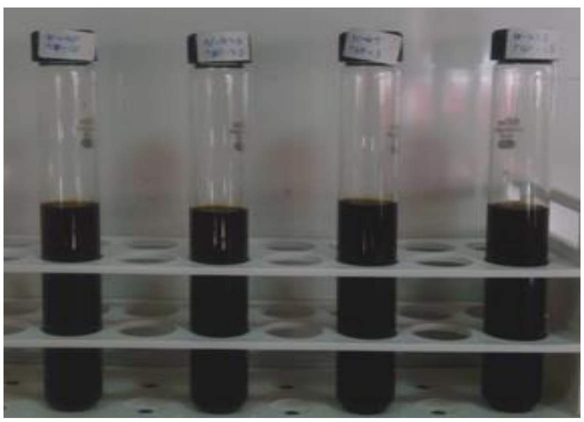

Fig 1: Formulations with Neem oil and surfactant Tween 80 after 4 weeks

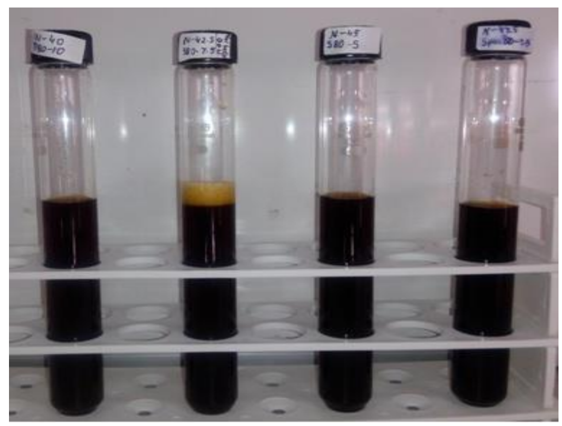

Fig 2: Formulation with Neem oil and surfactant Span 80 after 4 weeks

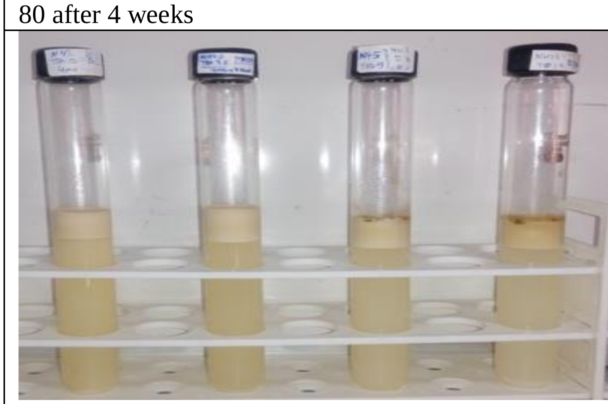

Fig 3: Formulation with Neem oil and surfactant Tween 80 dilution 10% after 4 weeks

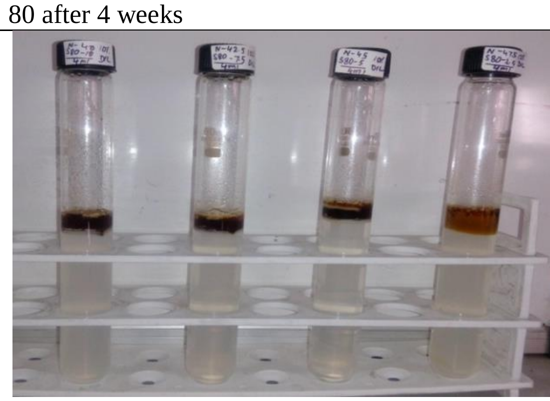

Fig 4: Formulation with Neem oil and surfactant Span 80 dilution 10% after 4 weeks

Table 2: Test tubes with different blend of T80 and S80

Test tube number	1	2	3	4	5	6	7	8	9
T80 (ml)	47.5	45	42.5	40	37.5	35	32.5	30	27.5
S80 (ml)	2.5	5	7.5	10	12.5	15	17.5	20	22.5

Test tube number	10	11	12	13	14	15	16	17	18
T80 (ml)	25	22.5	20	17.5	15	12.5	10	7.5	5
S80 (ml)	25	27.5	30	32.5	35	37.5	40	42.5	45

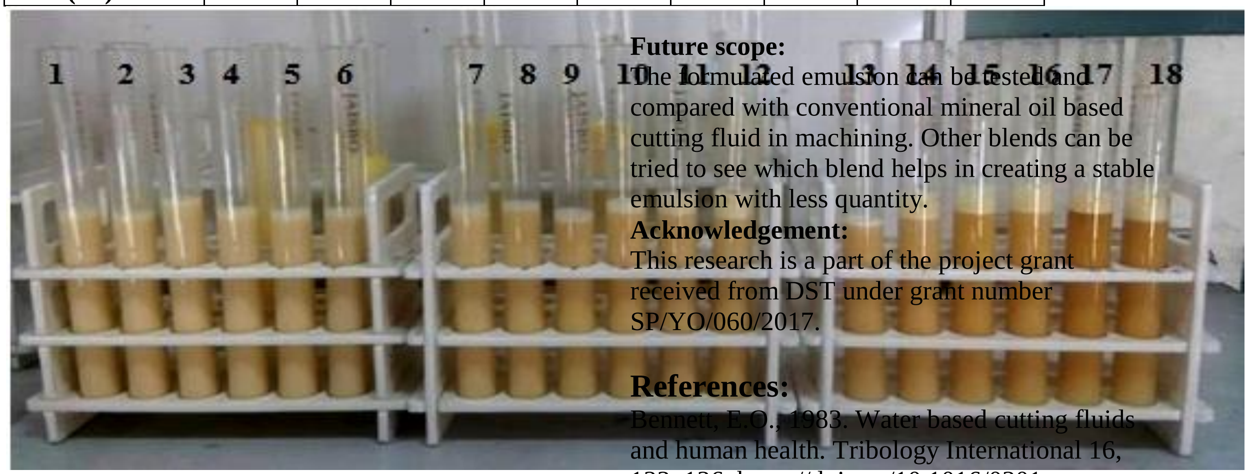

Figure 5: Samples with combination of surfactant T80 and S80 immediately.


Figure 6: Samples with combination of surfactant T80 and S80 after 1 day

Least amount of separation was observed in test tube number 12. This indicates that with the surfactant combination of T8 and S8, the best combination is at T8:S8::20:30.

Conclusion:

1. For development of a stable emulsion the correct composition has been found for the selected surfactant pair. The ratio for developing stable oil in water emulsion of Neem oil in water is found to be in the ratio 2:3 for T8 and S8.
2. It is also found that single surfactant is less effective in formulating a stable emulsion
3. Using blend of surfactant is effective in formulating a stable emulsion
4. When using blend of surfactant the quantity of emulsifier required is also less

Future scope:

The formulated emulsion can be tested and compared with conventional mineral oil based cutting fluid in machining. Other blends can be tried to see which blend helps in creating a stable emulsion with less quantity.

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References:

Bennett, E.O., 1983. Water based cutting fluids and human health. Tribology International 16, 133–136. https://doi.org/10.1016/0301-679X(83)90055-5

Binks, B.P., 2002. Particles as surfactants—similarities and differences. Interface Science 21.

Brinksmeier, E., Meyer, D., Huesmann-Cordes, A.G., Herrmann, C., 2015. Metalworking fluids—Mechanisms and performance. CIRP Annals 64, 605–628.

Byers, J.P., 2017. Metalworking fluids. Crc Press.

El Baradie, M.A., 1996a. Cutting fluids: Part I. Characterisation. Journal of Materials Processing Technology, International Conference on Advances in Material and Processing [illegible] https://doi.org/10.1016/0924-0136(95)01892-1

El Baradie, M.A., 1996b. Cutting fluids: Part II. Recycling and clean machining. Journal of Materials Processing Technology, International Conference on Advances in Material and Processing Technologies 56, 798–806. https://doi.org/10.1016/0924-0136(95)01893-X

Gauthier - 2003 - Metalworking Fluids Oil Mist and Beyond.pdf, n.d.

Goh, C.L., Gan, S.L., 1994. Efficacies of a barrier cream and an afterwork emollient cream against cutting fluid dermatitis in metalworkers: a prospective study. Contact Dermatitis 31, 176–180. https://doi.org/10.1111/j.1600-0536.1994.tb01960.x

Grattan, C.E.H., English, J.S.C., Foulds, I.S., Rycroft, R.J.G., 1989. Cutting fluid dermatitis. Contact Dermatitis 20, 372–376. https://doi.org/10.1111/j.1600-0536.1989.tb03175.x

Kajdas, C., 1989. Additives for metalworking lubricants - a review. Lubrication Science 1, 385–409. https://doi.org/10.1002/ls.3010010406

Kipling, M.D., 1977. Health hazards from cutting fluids. Tribology International 10, 41–46. https://doi.org/10.1016/0301-679X(77)90155-4

Lawal, S.A., Choudhury, I.A., Nukman, Y., 2012. Application of vegetable oil-based metalworking fluids in machining ferrous metals—a review. International Journal of Machine Tools and Manufacture 52, 1–12.

Nagendramma, P., Kaul, S., 2012. Development of ecofriendly/biodegradable lubricants: An overview. Renewable and Sustainable Energy Reviews 16, 764–774. https://doi.org/10.1016/j.rser.2011.09.002

Schulz, J., Brinksmeier, E., Meyer, D., 2013. On the Interactions of Additives in Metalworking Fluids with Metal Surfaces. Lubricants 1, 75–94. https://doi.org/10.3390/lubricants1040075

Shashidhara, Y.M., Jayaram, S.R., 2013. Experimental Determination of Cutting Power for Turning and Material Removal Rate for Drilling of AA 6061-T6 Using Vegetable Oils as Cutting Fluid [WWW Document]. Advances in Tribology. https://doi.org/10.1155/2013/362931

Shashidhara, Y.M., Jayaram, S.R., 2010. Vegetable oils as a potential cutting fluid—an evolution. Tribology International 43, 1073–1081.

Sluhan, C.A., n.d. Selecting the right cutting and grinding ,2008.

renewable fuels. Renewable Energy, *93*, pp.483-501.