Mechanical Testing and Diagnosis
ISSN 2247 – 9635, 2021 (XI), Volume 2, pp. 5-9

FLAMMABILITY TESTS FOR HEMP SEED OIL

Liviu Cătălin ȘOLEA, Lorena DELEANU

"Dunărea de Jos" University, Faculty of Engineering, Galati, Romania

corresponding author: csolea@ugal.ro

ABSTRACT

The objective of this study was to determine the lowest temperature at which hemp seed oil ignited (505°C) and also the highest temperature at which hemp seed oil did not ignite in at least three tests performed (500°C). The oil was tested on a cylindrical surface heated to various temperatures. A total of 16 tests were carried out to determine these two temperatures as accurately as possible. The tests were performed under the procedure complying with ISO 20823:2018, Petroleum and related products. Determination of the flammability characteristics of fluids in contact with hot surfaces. Manifold ignition test.

Keywords: Hemp seed oil, biolubricants, flammability, hot surface.

1. INTRODUCTION

Even though vegetable oils have different fatty acid compositions and concentrations, they have good lubricity, viscosity, flash point and low evaporative losses. All these characteristics have made many vegetable oils increasingly studied [1].

Hemp (Cannabis sativa L, of the Cannabis family Cannabaceae) has been cultivated for over 5000 years [2]. The world's largest producer of hemp is Canada. Worldwide, hemp is also grown on large areas in the USA, China, Chile, France, the Netherlands, Italy and South Korea. Until 1990 Romania ranked 3rd in the world and 1st in Europe in terms of hemp cultivation and processing [3], [4], [5], [6].

Cold pressing of hemp seeds yields an oil rich in polyunsaturated fatty acids (linoleic acid) and milling of these seeds yields a flour rich in protein as well as vitamins and minerals [3]. Table 1 shows the fatty acid composition of hemp seed oil in comparison with three other vegetable oils [7], [8], [9],[10].

Table 1. Fat acid composition of hemp oil and several vegetal oils

	Hemp	Olive	Rapeseed	Sunflower
Fatty acids	**[%]**			
C16:0	**6.4**	16.5	4.6	6.2
C18:0	**2.6**	2.3	1.7	2.8
C20:0	**0.8**	0.43	-	0.21
C16:1	**0.11**	1.8	0.21	0.12
C18:1	**11.5**	66.4	64.7	28.0
C18:2	**59.4**	16.4	19.6	62.2
C18:3	**3.36**	1.6	1.2	0.16
C20:1	**16.5**	0.3	9.1	0.18

Hemp and its products are used in many fields such as: textile industry, production of biofuels, food industry, pharmaceutical industry, medicine, construction etc. [3], [5], [6].

Researchers [11]-[16] have been involved in studies, using hemp seed oil as a biofuel.

In this work the behaviour of hemp seed oil in contact with a cylindrical surface heated at different temperatures was studied, thus the maximum temperature at which hemp seed oil did not ignite and the minimum temperature at which hemp seed oil ignited were determined.

2. EQUIPMENT AND PROCEDURE

In order to study the flammability behaviour of hemp seed oil, the installation described in the paper [17] was used (The installation is in the lubricants analysis laboratory of the Faculty of Engineering of ,,Dunărea de Jos" University of Galați).

The hemp seed oil was purchased from Canah International SRL (Romania), and it is certified to have saturated fat acids (11.95%wt), monosaturated fat acids (13.04%wt) and polysaturated fat acids (75%wt).

The procedure complies with ISO 20823:2018 Petroleum and related products - Determination of the flammability characteristics of fluids in contact with hot surfaces - Manifold ignition test [18].

The tests consist of dripping a quantity of 10 ml ± 0.5 ml of hemp seed oil onto the heated cylinder at various temperatures, the oil flow time being 50±5 seconds.

The oil flows gravitationally, distance between the end of the oil pipe and the upper surface of the heated cylinder is 300 mm.

The end of the oil pipe is positioned so that the oil droplets come into contact with the mid-length of the heated cylinder.

Before starting the tests, a procedure of oil flow adjustment is carried out, this adjustment was made using a valve.

After reaching the test temperature, wait 2-3 minutes for the temperature to stabilize at the surface of the cylinder and then perform the test.

All the carried out tests were recorded on video and the important events were reproduced in this paper as images.

After each test, the equipment was allowed for cooling down and then the cylinder was cleaned with isopropyl alcohol to remove all traces of burnt or unburnt oil.

3. EXPERIMENTAL RESULTS

The first temperature at which the tests started was 500°C, at this temperature the oil does not ignite, but when the oil comes into contact with the heated surface a lot of smoke is released (Fig. 1).

Fig. 1. Hemp oil, 500 °C, Test 1, 55th second

Fig. 2. Hemp oil, 525 °C, Test 1, 55th second

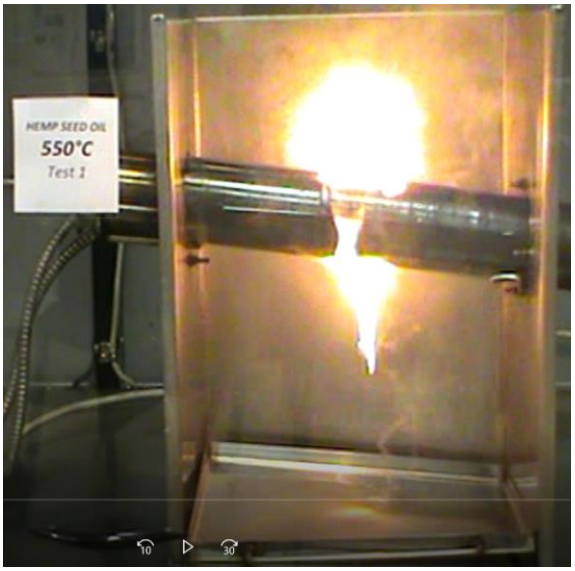

Fig. 3. Hemp oil, 550 °C, 3rd second

For the next test the temperature was increased to 525 °C, even at this temperature the hemp seed oil does not ignite (Fig. 2). Next the cylinder temperature is increased to 550 °C, at this temperature the oil ignites. The oil ignites very quickly, after only three seconds (Fig. 3) and burns throughout the test.

The temperature of 550 °C is a first minimum temperature at which flammability of hemp seed oil occurs, oil tested at any temperature above 550 °C would ignite.

For the next test, a temperature of 535 °C is chosen (approximately halfway between 525 °C and 550 °C).

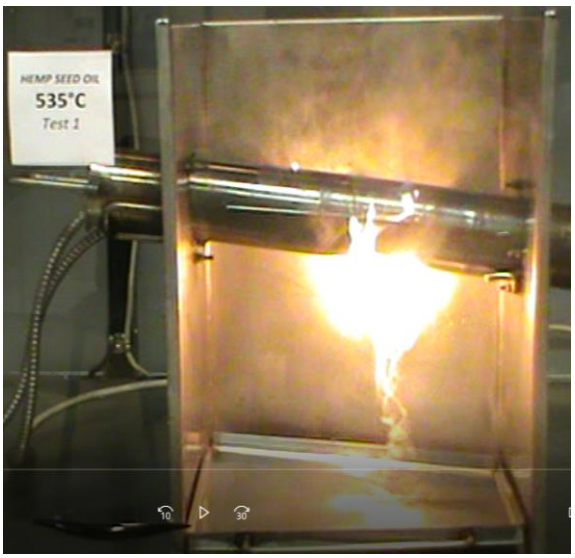

Fig. 4. Hemp oil, 535 °C, 3rd second

Also, in the case of the test carried out at 535 °C the oil burns very quickly (after three seconds) (Fig. 4), the burning of the oil is permanent during the test.

The temperature is lowered by 5 °C to 530 °C and test the oil. In this test the hemp seed oil ignites after

thirteen seconds (fig. 5), a large release of smoke is observed up to the moment of ignition.

Fig. 5. Hemp oil, 530 °C, 13rd second

For the next test, the temperature is lowered by 5°C and the behaviour of the oil is checked again at 525°C (Test 2). In this case the oil burns after the first three seconds (Fig. 6) and the burning continues throughout the test period.

Fig. 6. Hemp oil, 525 °C, Test 2, 3rd second

Lower the test temperature to 520 °C and find that the oil does not burn throughout the test. Assuming that this would be the maximum temperature at which hemp seed oil does not burn, repeat the test at this temperature. In the second test at 520 °C, the oil ignites after the first three seconds (Fig. 7).

The next test was carried out at 515 °C (a temperature with 5 °C lower than the previous one) and it can be seen that the oil does not ignite during the test period.

The test is repeated at temperature of 515°C and it is noted that the oil has ignited after only two seconds from the start of the test (Fig. 8).

Fig. 7. Hemp oil, 520 °C, (Test 2), 3rd second

Fig. 8. Hemp oil, 515 °C, (Test 2), 2nd second

Fig. 9. Hemp oil, 510 °C, 16th second

It the test is done at lower temperature of the hot manifold with 5 °C, that is the temperature of the hot surface is 510 °C. The oil has ignited after 16 seconds (Fig. 9). By the time of ignition, a large release of smoke is observed when the oil comes into contact with the heated surface of the cylinder. The burning of the oil is maintained throughout the test period.

Lower the cylinder heating temperature by 5 °C to 505 °C and test the oil. In this test the hemp seed oil ignites after eight seconds (Fig. 10).

Fig. 10. Hemp oil, 505 °C, 8th second

The hemp seed oil ignites at 505 °C and the next test is carried out at a temperature with 5 °C lower, so the oil was tested at temperature of 500 °C.

At this temperature the oil did not ignite and the test was repeated three more times (Fig. 11). Considering also the first test carried out at 500 °C (Fig. 1) at this temperature a total of five tests were carried out in which the hemp seed oil did not ignite.

Fig. 11. Hemp oil, 500 °C, 55th second (the 5th test at the same temperature)

The graph in Fig. 12 shows the tests' results in the order they were performed.

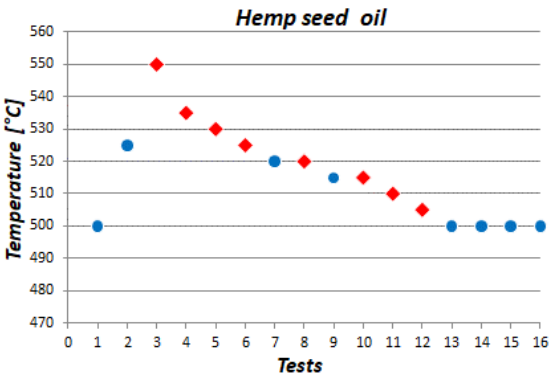

Fig. 12. Flammability tests for hemp seed oil, blue color – the oil does not burn, red color – the oil burns

Comparing this temperature with those determined from previous tests on other vegetal oils (Table 2), the authors concluded that the oil could be recommended in applications that involve contact or surface temperature less than 500 ºC, including cutting and as fluid for thermal treatment or heating fluid for rolling bearings in order to be mounted.

Table 2. The highest temperature for which the oil does not ignite, for several vegetal oils

Oil	The highest temperature for which the oil does not ignite [ºC]	Reference
Rapeseed oil	500	[19]*
Olive oil	485	[19]*
Corn oil	510	[19]*
Soybean oil	500	[19]*
Castor oil	490	[17]
Hemp seed oil	500	

* determined with 3 tests for which the oil does not ignite

4. CONCLUSIONS

Determination of the minimum flammability temperature on a hot surface of the hemp seed oil required 16 tests for having 5 tests with no ignition on hot surface. These are many than the standard ISO 20823:2018 (Petroleum and related products. Determination of the flammability characteristics of fluids in contact with hot surfaces. Manifold ignition test) required and the authors encourage to do more tests for determining this parameter.

The tests determined that the minimum temperature at which hemp seed oil ignites is 505 °C and the maximum temperature at which hemp seed oil does not ignite is 500 °C.

For all the tests where the oil did not ignite, it was observed that a lot of smoke was released when the oil

came into contact with the heated surface of the cylinder.

To increase the degree of accuracy, in determining the temperature at which hemp seed oil does not ignite on a hot surface, more than three tests should be carried out at the same temperature so, at the maximum temperature at which the tested oil does not ignite, five tests were carried out, and during all these tests the oil does not ignite.

REFERENCES:

[1] Panchal, T.M., Patel, A., Chauhan, D.D., Thomas, M., Patel, J.V., A methodological review on bio-lubricants from vegetable oil based resource, *Renewable and Sustainable Energy Reviews*, **70**, 65-70, 2017.

[2] Vonapartis, E., Aubin M.P., Seguin, P., Mustafa, A.F., Seed composition of ten industrial hemp cultivars approved for production in Canada, *Journal of Food Composition and Analysis*, **39**, 8-12, 2015.

[3] Dabija A., Tehnologie. Materii prime inovative pentru industria de panificaţie, Brutarul & cofetarul, https://brutarul.ro/tehnologie-materii-prime-inovative-pentru-industria-de-panificatie-40/, 2020.

[4] Piatirka svitovykh vyrobnykiv konoplianoho nasinnia, Asotsiatsiia «Ukrainski tekhnichni konopli», Available at: http://www.tku.org.ua/uk/news/5186, 2016.

[5] Oseyko M., Sova N., Lutsenko M., Kalyna V., Chemical aspects of the composition of industrial hemp seed products, *Ukrainian Food Journal*, **8(3),** doi: 10.24263/2304- 974X-2019-8-3-11, 2019.

[6] Borhade S.S., Chemical Composition and Characterization of Hemp (Cannabis sativa) Seed oil and essential fatty acids by HPLC Method, *Archives of Applied Science Research*, **5(1),** 5-8, 2013.

[7] Syahir, A.Z., Zulkifli, N.W.M., Masjuki, H.H., Kalam, M.A., Abdullah Alabdulkarem; Gulzar, M., Khuong, L.S., Harith, M.H., A review on bio-based lubricants and their applications, *Journal of Cleaner Production*, **168**, 997-1016, 2017.

[8] Orsavova, J., Misurcova, L., Ambrozova, J., Vicha, R., Mlcek, J. Fatty acids composition of vegetable oils and its contribution to dietary energy intake and dependence of cardiovascular mortality on dietary intake of fatty acids, *International Journal of Molecular Science*, **16**, 12871, 2015.

[9] Zambiazi, R.C., Przybylski, R., Zambiazi, M.W., Mendonca, C.B., Fatty acid composition of vegetable oils and fats, *Boletim Centro de Pesquisa de Processamento de Alimentos*, Curitiba, 25, doi: http://dx.doi.org/10.5380/cep.v25i1.8399, 2007.

[10] Salimon J., Noor, D.A.M., Nazrizawati, A., Firdaus, M.M., Noraishah, A., Fatty acid composition and physicochemical properties of malaysian castor bean Ricinus communis L., seed oil, *Sains Malaysiana*, **39**, 761-764, 2010.

[11] Teja, N.B., Hafeez, M.M.A., Surendran, G., Rajeshwaran, M., Alagumurthi, N., Investigations of performance and emission characteristics in diesel engine fueled with Hemp oil methyl ester. *Materials Today*: Proceedings. 2020.

[12] Parvez, A.M., Lewis, J.D., Afzal. M.T, Potential of industrial hemp (Cannabis sativa L.) for bioenergy production in Canada: Status, challenges and outlook, *Renewable and Sustainable Energy Reviews*, **141**, 110784, 2021;

[13] Tulaphol, S., Sun, Z., Sathitsuksanoh, N., Biofuels and bioproducts from industrial hemp, *Advances in Bioenergy*, 2021.

[14] Asokan, M.A., Prabu, S.S., Bollu, A., Reddy, M.A., Ram, A., Sukhadia, D.S., Emission and performance behavior of hemp seed oil biodiesel/diesel blends in DI diesel engine, *Materials Today: Proceedings*, 2021.

[15] Viswanathan, M.B., Cheng, M.H., Clemente, T.E., Dweikat, I., Singh, V., Economic perspective of ethanol and biodiesel coproduction from industrial hemp, *Journal of Cleaner Production*, **299**, 126875, 2021.

[16] Hebbal, O.D., Reddy, K.V., Rajagopal, K., Performance characteristics of a diesel engine with deccan hemp oil, *Fuel* **85**, 2187–2194, 2006;

[17] Șolea, L.C., Deleanu, L., Flammability tests on hot surface for castor oil, Mechanical Testing and Diagnosis (X), **4**, 24-28, https://doi.org/https://doi.org/10.35219/mtd, 2020.

[18] ISO 20823:2018, Petroleum and related products. Determination of the flammability characteristics of fluids in contact with hot surfaces. Manifold ignition test.

[19] Șolea, L.C., Contributions on Studying the rheological and tribological Behavior of biodegradable Lubricants based on Vegetal Oils (in Romanian), PhD thesis, "Dunarea de Jos" University, Galati, Romania, 2013.