

# Cold Temperature Properties of Fatty Acid Methyl Esters

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The cold temperature properties of fuels are in the moderate and arctic climatic regions an essential parameter for the practical use of vehicles. For determining the cold temperature behaviour of transport fuels the methods of Cold Filter Plugging Point (CFPP), Cloud Point (CP) and Pour Point (PP) are used. The determination of these parameters based on specific standards is done in laboratories mostly with automatically operated apparatus. The target of the presented project was the development of a model for the prediction of the CFPP, CP and PP of Fatty Acid Methyl Esters (FAME) based on their fatty acid distribution.

The compilation of the melting points of individual FAME is based on the Beilstein Database. For some of the respective FAME a large number of data are available. Of these individual data average values and median values have been calculated. In general it can be stated that the respective melting point is increasing with increasing carbon chain and decreasing dramatically with increasing number of double bounds in the carbon chain (see figure 1). The red squares show the respective values for the FAME with double bounds.

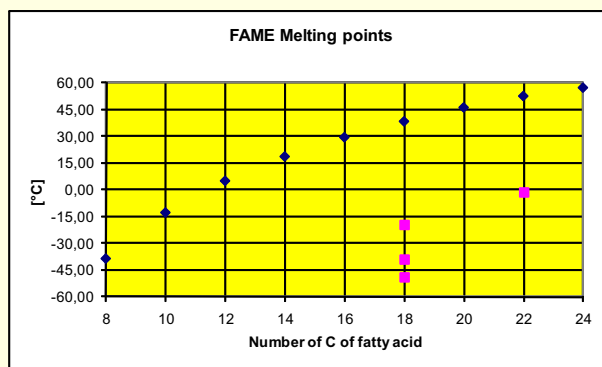


Figure 1: Melting points of different FAME versus their C-chain-length<sup>1</sup>

For the development of the statistical model some 102 different FAME-samples have been prepared in the laboratory, in the pilot plant or have been collected from real operated production plants. The used raw materials are covering a wide range coming from different regions all over the world (e.g. Rapeseed oil, Sunflower oil, Soybean oil, Palm oil, Jatropha oil, Animal fats, Coconut fat, Used frying oil, Blends). For the respective FAME the Average, Median, Minimum and Maximum content are listed. The iodine value ranges from 10 till 189 [g Iod / 100 g FAME]. From all samples the parameters CFPP, CP and PP have been determined. The minimum values for CFPP | CP | PP are -33 | -38 | -38°C. The maximum values for CFPP | CP | PP are +13 | +14 | +14°C.

These data have been used for multiple regression analysis with SPSS. In equation (1) to (3) the calculations for the CFPP | CP | PP are shown. The amount of the respective FAME has to be inserted as decimal fraction (e.g. 23 % of C 18:1 have to be inserted in the equation as 0,23). The results of the multiple regression between fatty acid distribution and CFPP, CP or PP were for the coefficient of determination ( $R^2$ ) at 0,72 – CFPP, 0,66 – CP and 0,89 – PP. In the figures 2 to 4 the respective values of the determined and calculated CFPP | CP and PP are compared graphically.

These developed equations enable to estimate quickly the CFPP | CP | PP on the basis of the fatty acid distribution of different raw materials.

$$\text{Eq. (1): } \text{CFPP}[\text{°C}] = \text{C18:3} \cdot -17,860 + \text{C18:0} \cdot 66,075 + \text{C18:1} \cdot -13,398 + \text{C22:0} \cdot 533,206 + \text{C18:2} \cdot -14,958 + \text{C12:0} \cdot -12,453 + \text{C16:0} \cdot 27,78$$

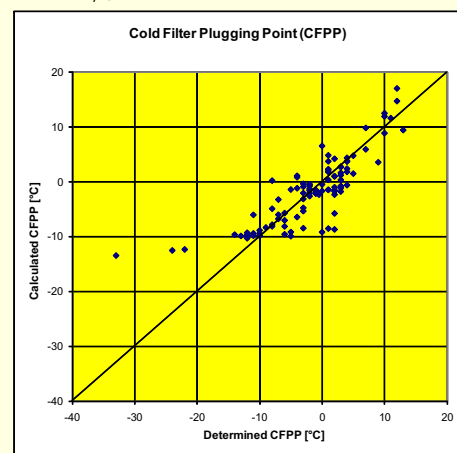


Figure 2: CFPP<sub>determined</sub> versus CFPP<sub>calculated</sub>

$$\text{Eq. (2): } \text{CP}[\text{°C}] = \text{C18:3} \cdot -18,578 + \text{C16:0} \cdot 31,909 + \text{C18:1} \cdot -11,554 + \text{C12:0} \cdot -25,653 + \text{C18:2} \cdot -13,453 + \text{C22:0} \cdot -334,926 + \text{C18:0} \cdot 61,230$$

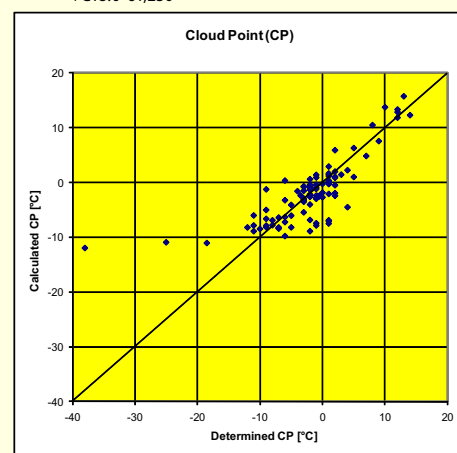


Figure 3: CP<sub>determined</sub> versus CP<sub>calculated</sub>

$$\text{Eq. (3): } \text{PP}[\text{°C}] = \text{C18:1} \cdot -24,374 + \text{C18:0} \cdot 77,458 + \text{C18:2} \cdot -17,014 + \text{C12:0} \cdot -26,846 + \text{C16:0} \cdot 44,137 + \text{C22:0} \cdot 283,138 + \text{C22:1} \cdot -28,824 + \text{C18:3} \cdot -19,035 + \text{C20:0} \cdot 184,402$$

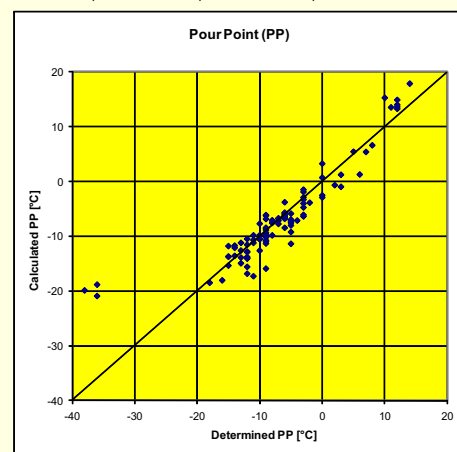


Figure 4: PP<sub>determined</sub> versus PP<sub>calculated</sub>

<sup>1</sup> Own diagram, based on „Beilstein“-Data