Investigating the oxidation stability of cannabis products with RapidOxy 100

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Hemp products, above all CBD (Cannabidiol), have become widely used ingredients in many industries. Whether cannabinoids are used for an anti-inflammatory effect in skin care products or as a natural way to help with anxiety, or sleep disorders in pharmaceuticals, their chemical structure similar to messengers of the human body is key. However, in many cases autoxidation can be the root cause for chemical changes affecting not only quality, but most of all the efficiency of contained cannabinoids independent from product type. To exclude a decrease or worse a loss of efficacy during the shelf life of the product means to guarantee the corresponding oxidation stability. Keeping this in mind, during product development or reformulation, it is absolutely crucial not only to draw up the respective methods for the required oxidation stability but also prove their effectiveness. For the latter, Anton Paar's RapidOxy 100 is a highly effective tool.

RapidOxy 100 artificially accelerates the oxidation process by using increased temperature and an excess of pure oxygen. The whole measuring process is fully automatic, limiting error sources to a minimum. One of the major benefits is its applicability with all kinds of products because you can measure fluid, semi-solid, and solid samples without any prior sample preparation. It lets you investigate the oxidative behaviour of the product as a whole while additionally saving you a lot of time. Information about the whole product is better than knowing just the oxidation stability of a single ingredient that might be influenced chemically by other molecules within the entire matrix of the product.

Figure 1: RapidOxy 100.

Due to the defined oxygen volume in the closed test chamber, you can calculate the oxygen consumption. Moreover, for the majority of products you can observe Arrhenius behaviour regarding the applied temperature, which lets you determine the activation energy of a specific oxidation process and in case of fats and oils additionally allows you to estimate the shelf life. With the OxyLogger 100 PC software, all of these valuable investigation options are available [1, 2, 3, 4].

The Rapid Small-Scale Oxidation Test (RSSOT)

During a RapidOxy 100 measurement the sample is exposed to an excess of pure oxygen (up to 700 kPa) and elevated temperature (up to 180°C). Typical conditions of the method are temperatures between 80°C and 140°C and an initial oxygen pressure of 700 kPa to initiate a rapid oxidation process. The oxygen uptake of the sample during the measurement is monitored by recording the pressure until a predefined pressure drop or a specific time. The elapsed time until the pressure drop or the extent of the pressure drop within a specific time is directly related to the total oxygen consumption and therefore to the oxidation stability of the sample.

A standard measurement determines the induction period (IP) which is defined as the time elapsed between starting the heating procedure of the sample vessel and a pressure drop of 10% from the maximum pressure (= Breakpoint), measured in minutes *(see Figure 2)*. The pressure drop from maximum pressure is directly related to the oxygen uptake of the sample.

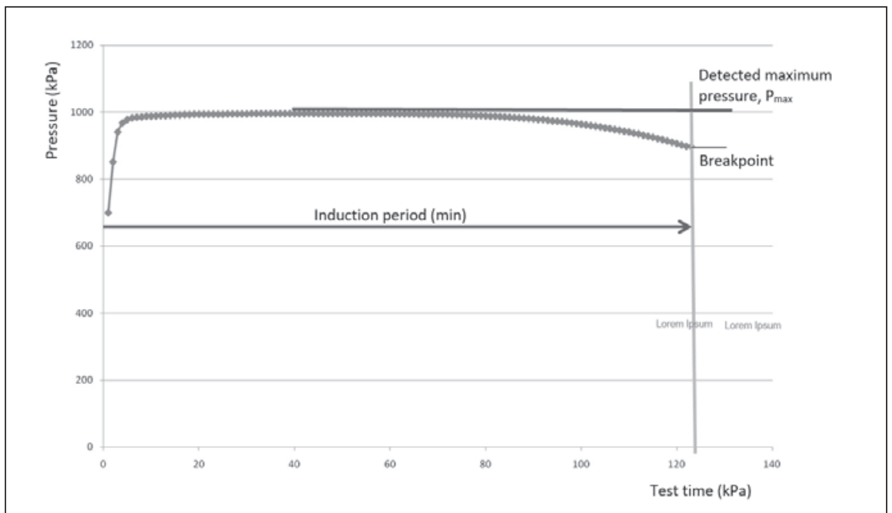

Figure 2: Determination of the induction period (IP).

The induction period of a sample reflects the time for its oxygen uptake and can even give information on the amount and rate of it. The principle is straightforward: Samples with a shorter induction period are usually less stable towards oxidation than samples with a longer induction period.

Since even solid samples can be measured without prior sample preparation, you can investigate the oxidation stability of complex products.

The major advantages of this method are the significantly reduced measurement time and high precision, both allowing quick and direct measurements of the oxidation stability during product development and reformulation [3, 4, 5, 6].

Investigating the oxidation stability of oil containing cannabinoids

Oxidation stability of different cannabinoids

This section demonstrates the benefits of the Rapid Small-Scale Oxidation Test when it comes to determining the oxidation stability of formulations containing cannabinoids.

In the described study an MCT (Medium Chain Glyceride) oil which is commonly used for cosmetics and pharmaceuticals served as the carrier oil. To determine the oxidation stability order of MCT oil with different cannabinoids with the RSSOT, the following samples were investigated:

MCT oil, pure
Sample C1: 20 mg/mL CBD and 10 mg/mL THC extract
Sample C3: 20 mg/mL CBD extract
Sample C5: 20 mg/mL THC extract

The oxidation stability order of the different cannabinoids could be screened using the parameters described below:

Temperature: 100°C
Initial filling pressure: 700 kPa
Stop criterion: pmax – 5%
Sample volume: 5 mL

A high precision of test results was demonstrated for all samples *(see Table 1)* and a clear trend of stabilities could be determined from the measured induction periods *(see Figure 3)*.

Table 1: Repeatability of test results.

	MCT oil	**Sample C1**	**Sample C3**	**Sample C5**
IP in minutes	3676.90 3709.97	572.21 574.95	266.53 266.26	1366.45 1376.02
Repeatability	0.9	0.5	0.1	0.7

As expected, the MCT oil has a very high oxidation stability which is reflected in a comparably long IP. Whereas sample C3 and its contained CBD extract is by far the least stable formulation, the combination of CBD and THC extract in sample C1 leads to a stability and IP in between samples C1 and C5. The measured IP values demonstrate the effectiveness of the measuring principle.

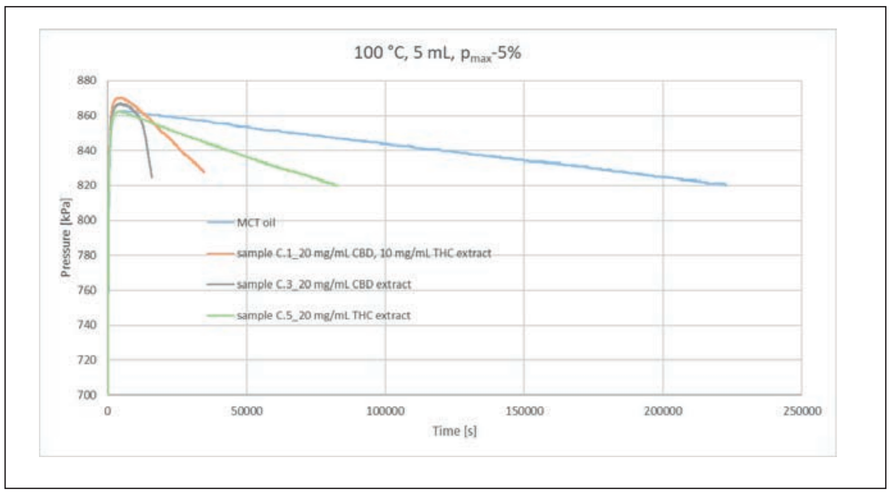

Figure 3: Determination of the oxidation stability order of different cannabinoids.

Arrhenius dependency and calculation of oxygen consumption

Due to measuring the oxygen uptake of a sample via a corresponding pressure drop in a closed test chamber, a variety of investigation options with the RSSOT are possible. For simple comparison and automatic evaluations of measurement curves, the OxyLogger 100 desktop software is available.

Arrhenius dependency and calculation of activation energy

Typically, the induction period of a sample shows an Arrhenius dependency on the applied test temperature. In our example of the MCT oil you can see the pure comparison of the measurement curves from OxyLogger 100 at different temperatures (120°C, 140°C, 160°C) in *Figure 4*.

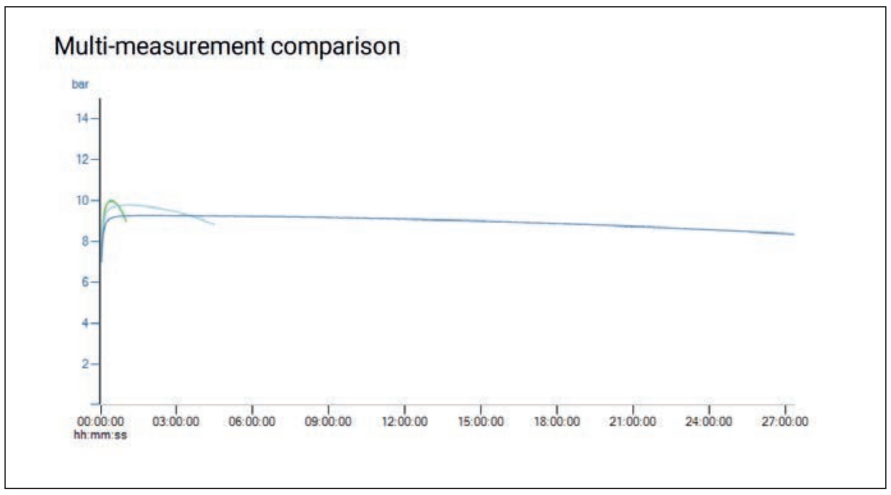

Figure 4: Measurement curves of pure MCT oil at different temperatures.

We carried out the same study with MCT oil containing CBD. For both – the pure oil and the oil with CBD – we plotted the derived IPs in a corresponding Arrhenius graph (see Figure 5) with OxyLogger 100. The software automatically calculated the activation energy for the oxidation reaction from the slope of the respective graph. As you can see below, the activation energy that is necessary is significantly higher for the pure oil without contained cannabinoid *(see Figure 5)*.

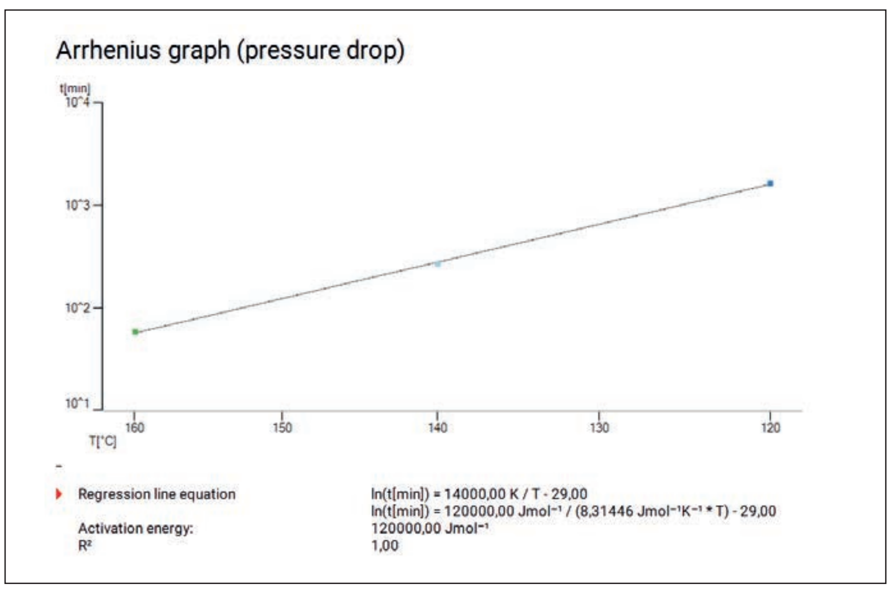

Figure 5a: Arrhenius graph and calculation of activation energy from measurement at different temperatures of pure MCT oil

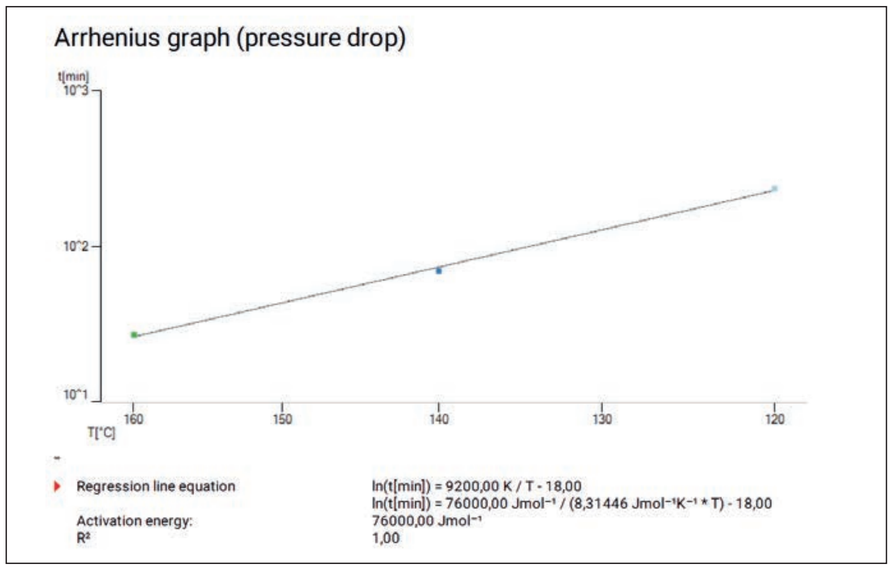

Figure 5b: Arrhenius graph and calculation of activation energy from measurement at different temperatures of MCT oil containing CBD

Oxygen uptake calculation

Thanks to the closed test chamber and the general measuring principle of the Rapid Small-Scale Oxidation Test, all values for calculating the oxygen consumption according to the following equation are readily available if the volume of the sample (or weight and density in case of solid food products) is known:[2]

$$\Delta[O_2]_t = \frac{(p_{max} - p_t)}{RT} \cdot \frac{(V_{tot} - V_{liq})}{V_{liq}}$$

Where

$\Delta[O_2]_t$	Oxygen consumption
p_{max}	Maximum pressure
p_t	Pressure after a specified time
R	Real gas constant R=8.314 kg • m^2 • s$^{(-2)}$ • mol$^{(-1)}$ • K$^{(-1)}$
T	Measurement temperature
V_{tot}	Volume of test chamber, 28.5 mL
V_{liq}	Sample volume

With OxyLogger 100, the result is available automatically. When choosing the calculation with a right click, the calculation is automatically applied at the end point of the measurement. However, every point on the pressure curve that is of interest can be added when chosen. For MCT oil, you can see the OxyLogger 100 calculation, including one additional pressure/time point, in *Figure 6*.

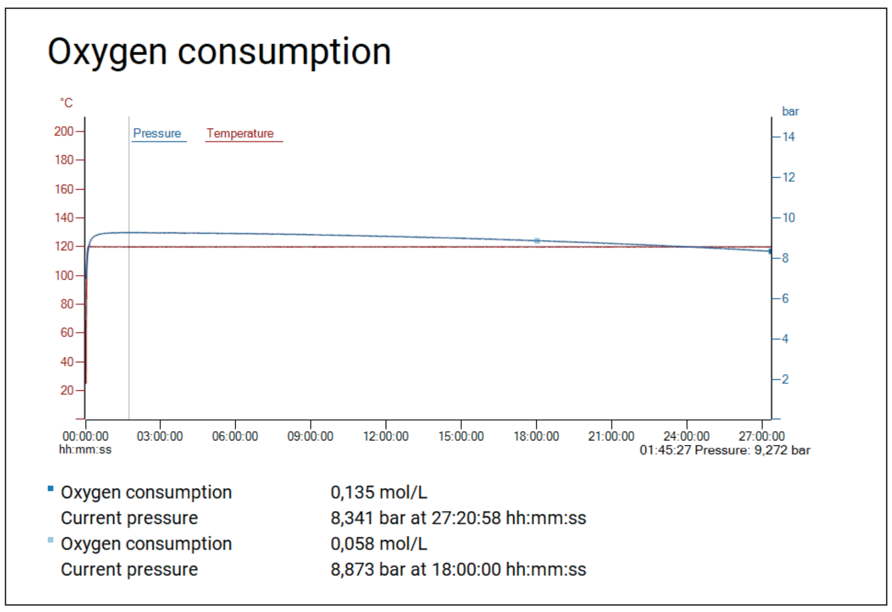

Figure 6: OxyLogger 100 calculation of oxygen consumption of MCT oil at 120°C.

Further investigation possibilities: Oxidation Induction Time and shelf-life estimation

The Oxidation Induction Time (OIT) is another way to evaluate the pressure time curve derived from a measurement with RapidOxy 100. It is the point of time where the pressure drop shifts significantly (e.g., when all antioxidants are consumed and the raw product starts to oxidise, or initial peroxides are formed and the oxidation reaction of a sample becomes very rapid). To determine the OIT, you need to typically conduct the measurement until a pressure drop higher then pmax-10% (e.g., to 40%).

You can estimate shelf life with OxyLogger 100 by extrapolating the Arrhenius graph of the results (IP or OIT can be selected) to room temperature. By default, the software provides the estimate for 40°C, 25°C, and 20°C, but it can be customised to specific temperatures used during storage, transport, etc. by simply adding the respective temperature value.

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Summary

With the Rapid Small-Scale Oxidation Test, the RapidOxy 100 offers a quick, easy, and reliable method to investigate formulas and products containing cannabinoids with regards to oxidation stability and product quality. The unique measuring principle leads to a significantly reduced measuring time for the described investigations. Additionally, the straightforward principle gives rise to many further possibilities to access the oxidative behaviour of samples. By evaluating the pressure/time curve with OxyLogger 100 further, you can conduct automatic calculations of consumption, activation energy, and much more. Major benefits are its ease of use and fully automatic measurements. Since weighing in the sample is the only manual step, you minimise error sources as well. Independent from sample consistency, no sample preparation is necessary prior to the measurement. Therefore, you can investigate the oxidative behaviour of a sample as a whole.

References

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