

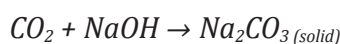
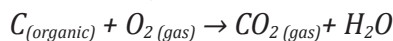
WTW OxiTop® for Biodegradation Determination

Introduction

Biodegradation is defined as the biologically catalysed reduction in complexity of chemical compounds. It is the process by which organic substances are broken down into smaller compounds by living microbial organisms (Joutey, 2013). Biodegradation plays a great role in environmental remediation (bioremediation), and also has been known as a evaluation tool for man-made chemicals. WTW OxiTop® has been demonstrated as an effective tool to evaluate the biodegradation (Vähöja et al., 2005).

Measurement of Biodegradation by an Oxitop® System

The WTW OxiTop® system (Fig. 1) utilizes a pressure sensor to determine the pressure drop in gaseous phase in a closed vessel at a constant temperature. The pressure drop is due to the following basic fundamentals of respiration with CO₂ being absorbed by NaOH pellets. The pressure drop is recorded by a data logger in the OxiTop®



There are many standard methods published to evaluate biodegradation, the mostly used methods have been summarized in Table 1 and the general calculation described as following

OECD 301 A~F method

In these methods degradation is followed by the determination of parameters such as DOC, CO₂ production and oxygen uptake. Measurements are taken at sufficiently frequent intervals to allow the identification of the beginning and end of biodegradation. Normally, the test lasts for 28 days. When specific OECD method are determined, the general calculate primary biodegradation from:

$$Dt = \frac{Sb - Sa}{Sb} \times 100$$

- Dt: % Primary degradation at time t, normally 28 days
- Sb: Residual amount of test chemical in inoculated medium at end of the test (mg)
- Sa: Residual amount of test chemical in the abiotic control at the beginning of the test (mg)

ISO Method

1. Aerobic biodegradation

In this method, oxygen demand is determined to evaluate of biodegradability, the general formula can be summarized as following,

$$Degradation (\%) = \frac{BOD_{test} - BOD_{control}}{ThOD} \times 100$$

Degradation: % primary degradation

BOD test: The BOD value of the sample after reaction (mg)

BOD control: The BOD value of the control sample (mg)

ThOD: The theoretical oxygen demand

2. Anaerobic biodegradation

In this method, anaerobic biodegradation of materials is determined by biogas measurement

$$Biodegradability (\%) = \frac{\sum Vs - \sum Vb}{\sum Vmax} \times 100$$

Vs: The total CO₂ and CH₄ volume from the sample vessel

Vb: The total CO₂ and CH₄ volume from the blank vessel

Vmax: The maximum theoretical volume of the biogas (CO₂ + CH₄)



Fig. 1 OxiTop® for biodegradation

Table 1, Biodegradation related standard method and articles by using OxiTop® system.

Category	The Standard	Description (Development, 2022)(Standardization, 2022)	Reported articles by using OxiTop® system
Aerobic & Anaerobic	OECD 301-A~F	In this Guideline six methods are described that permit the screening of chemicals for ready biodegradability in an aerobic aqueous medium.	(Report, Gartiser, Hydrotox GmbH, 2001)
	OECD 306	This Test Guideline describes two methods for biodegradability in seawater.	(化学物質評価研究機構, 2011)
Aerobic biodegradation	ISO 14855-2:2018	Determination of the ultimate aerobic biodegradability of plastic materials under controlled composting conditions – Method by analysis of evolved carbon dioxide – Part 2: Gravimetric measurement of carbon dioxide evolved in a laboratory-scale test	(Verstichel and Beeckman, 2020)(Sikorska et al., 2019)(Silveira et al., 2019)
	ISO 14851:2019	Determination of the ultimate aerobic biodegradability of plastic materials in an aqueous medium – Method by measuring the oxygen demand in a closed respirometer	(Olalla, Sara and Ricardo, 2021)(López-ibáñez and Beiras, 2022)(Rapisarda et al., 2020)(Silveira et al., 2019)
	ISO 14852:2021	Determination of the ultimate aerobic biodegradability of plastic materials in an aqueous medium – Method by analysis of evolved carbon dioxide	Depends on if the system is closed, CO ₂ value will be measured by titration.
	ISO 17556:2019	Plastics – Determination of the ultimate aerobic biodegradability of plastic materials in soil by measuring the oxygen demand in a respirometer or the amount of carbon dioxide evolved	(Borowicz et al., 2019)(Szpiżyk, Lubczak and Lubczak, 2021)
	ISO 19679:2020	Plastics – Determination of aerobic biodegradation of non-floating plastic materials in a seawater/sediment interface – Method by analysis of evolved carbon dioxide	Depends on if the system is closed, CO ₂ value will be measured by titration.
	ISO 23977-1:2020	Plastics – Determination of the aerobic biodegradation of plastic materials exposed to seawater – Part 1: Method by analysis of evolved carbon dioxide	Depends on if the system is closed, CO ₂ value will be measured by titration.
	ISO 23977-2:2020	Plastics – Determination of the aerobic biodegradation of plastic materials exposed to seawater – Part 2: Method by measuring the oxygen demand in closed respirometer	(López-ibáñez and Beiras, 2022)
	ISO 18830:2016	Plastics – Determination of aerobic biodegradation of non-floating plastic materials in a seawater/sandy sediment interface – Method by measuring the oxygen demand in closed respirometer	(化学物質評価研究機構, 2011)

Category	The Standard	Description (Development, 2022)(Standardization, 2022)	Reported articles by using OxiTop® system
Anaerobic biodegradation	ISO 14853:2016	Plastics – Determination of the ultimate anaerobic biodegradation of plastic materials in an aqueous system – Method by measurement of biogas production	(Zaborowska et al., 2021) (Bernat et al., 2021)
	ISO 15985:2004	Plastics – Determination of the ultimate anaerobic biodegradation and disintegration under high-solids anaerobic-digestion conditions – Method by analysis of released biogas	Depends on if the system is closed
	ISO 13975:2019	Plastics – Determination of the ultimate anaerobic biodegradation of plastic materials in controlled slurry digestion systems – Method by measurement of biogas production	Depends on if the system is closed
	ISO 10210:2012	Plastics – Methods for the preparation of samples for biodegradation testing of plastic materials	(Tachibana et al., 2021)
Composting condition	ISO 16929:2021	Plastics – Determination of the degree of disintegration of plastic materials under defined composting conditions in a pilot-scale test	Depends
	ISO 17088:2021	Plastics – Organic recycling – Specifications for compostable plastics	Depends
	ISO 20200:2015	Plastics – Determination of the degree of disintegration of plastic materials under simulated composting conditions in a laboratory-scale test	Depends

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