BIODEGRADATION TESTING SERVICES

by: RAZMAH GHAZALI and SALMIAH AHMAD

MAY 2002

161

MPOB TT No. 144

MPOB INFORMATION SERIES ISSN 1511-7871

Biodegradation, as the principal mechanism operating in sewage treatment plants and in the self-cleaning processes at surface waters, decides the fate of a substance in the environment and indicates whether it is likely to have a toxic effect on aquatic organisms. Biodegradation is the least expensive and most widely used technique for removing organic compounds from wastewater and is the primary mechanism responsible for their destruction in nature (Mohd Naziruddin *et al.*, 1995).

THE IMPORTANCE OF ENVIRONMENTAL EVALUATION

The evaluation of raw materials in consumer products in relation to their adverse effects to aquatic environment is now of critical importance in many industries throughout the world (Sturm, 1973). Nowadays, the biodegradability of a material to be used in a consumer product is considered as important as its performance.

The reason for determining biodegradability in the laboratory is to predict the fate and persistence of chemicals in the environment. Under various national and international laws, when a new chemical likely to enter the environment is to be registered, information on its biodegradability has to be supplied. Evaluation of a major new material should therefore include biodegradability testing as an important step in its environmental assessment.

The biodegradation data can be used in the preparation of material safety datasheet, registration of products, improving production process, *etc.*

DEFINITION OF BIODEGRADATION

Biodegradation can be defined as any process mediated by living organisms that results in the conversion of a chemical into organic and/or inorganic end-products that are chemically distinct from the parent material (Speel, 1963; Swisher, 1987; Larson *et al.*, 1993) (*Figure 1*). Biodegradability can mean susceptibility to complete decomposition to compounds such as carbon dioxide and water, or merely decomposition to a point where a detergent (for example) loses its ability to produce foam or act as a surfactant (Speel, 1963).

Aerobic Environment

Organic compounds + O_2 ⟶ CO_2 + H_2O + Biomass + Metabolites + Organic compounds (unreacted)

Anaerobic Environment

Organic compounds ⟶ CO_2 + CH_4 + H_2O + Biomass + Metabolites + Organic compounds (unreacted)

Figure 1. Chemistry of biodegradation.

BIODEGRADATION TEST METHODS

The tests for ready biodegradability have been developed as screening methods, which can be easily and inexpensively carried out in the laboratory to decide whether a chemical can be readily biodegraded in the aquatic environment.

Numerous biodegradability test methods have been standardized by organizations such as the OECD, ASTM, EPA, ISO and MITI. The most commonly used methods are those published by the OECD. Therefore, tests employed in this laboratory are based on the OECD Guideline for Testing of Chemicals.

Biodegradation is measured by exposing a test compound to microorganisms and analysing the system at intervals to determine the disappearance of the test compound, the formation of degradation products or the uptake of oxygen. Biodegradation may be assessed by measuring biochemical oxygen demand (BOD - the amount of oxygen consumed by microorganisms when metabolizing a test compound), dissolved organic carbon (DOC - organic carbon present in solution or that which passes through a 0.45 µm filter or remains in the supernatant after centrifuging at approximately 4000xg for 15 min) and carbon dioxide (CO_2) evolution.

A substance may be considered to be readily biodegradable if the following percentage of biodegradation is achieved in 28 days (OECD, 1992):

- dissolved organic carbon (DOC) 70%
- O_2 uptake as a percentage of theoretical O_2 demand (ThOD – the total amount of oxygen required to oxidize a chemical completely) 60%
- CO_2 generation as a percentage of theoretical carbon dioxide ($ThCO_2$ - the quantity of carbon dioxide calculated to be produced from the known or measured carbon content of the test compound when fully mineralized) 60%

BIODEGRADATION TESTING SERVICES

A laboratory has been set-up in AOTC, MPOB to establish the biodegradation characteristics of products mainly derived from palm oil or palm kernel oil (*Figure 1*). The laboratory is well equipped to carry out routine biodegradation studies or testing and has been in operation since 1997.

Figure 1. Laboratory for biodegradability tests.

There are four ready biodegradability tests that are available and the cost for each test is indicated in *Table 1*.

The standard methods for testing and evaluation of biodegradability require that the test substance be soluble in water at the test concentration (OECD, 1992). This is important since only in this case, the transfer of test results to practical environmental situations is possible.

TABLE 1. BIODEGRADATION TESTING SERVICES AVAILABLE IN MPOB

Test	Description	Cost/test
OECD 301A	DOC Die-Away Test – degradation is followed by DOC analysis at frequent intervals over a 28-day period.	RM 300
OECD 301B	CO_2 Evolution Test – degradation is followed over 28 days by determining the CO_2 produced.	RM 340
OECD 301D	Closed Bottle Test – degradation is followed by analysis of dissolved oxygen at frequent intervals over a 28-day period.	RM 270
OECD 301E	Modified OECD Screening Test (STURM test) – similar to the DOC Die-Away Test but employs a relatively low concentration of microorganisms.	RM 300

The time required to perform each test and to prepare the final report in English is about two to three months after receipt of sample. In order to perform the test, the safety datasheet (if any) and approximately 50 g of the substance is required. The chemical structure or formula of the test material, the purity or the relative proportions of major components of the test material is also required in order to calculate the theoretical values and to interpret the results obtained.

For more information, kindly contact Razmah Ghazali at razmah@mpob.gov.my or Dr Salmiah Ahmad at salmiah@mpob.gov.my, or at AOTC, MPOB, Lot 9 & 11, Jalan P/14, Seksyen 10, 43650 Bandar Baru Bangi, Selangor. Tel. No. 03-89255708 and Fax No. 03-89256197.

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For more information kindly contact:

Director-General
MPOB
P. O. Box 10620
50720 Kuala Lumpur, Malaysia.
Tel: 03-89259155, 89259775,
Homepage: http: //mpob. gov. my
Telefax: 03-89259446