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From.: Zu-sp
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REPORT

Order No.: 18767/1-I **page 1 of 7 pages**
Modified version; replaces test report no. 18767/1 from 21 Oct. 2019

Client: Karlsruher Institut für Technologie
Lichttechnisches Institut
Engesserstr. 13
76131 Karlsruhe

Date of order: 15 May 2019

Receipt of sample material: 19 June 2019 and 11 July 2019

Origin of sample material: From the client

Purpose: Examination for biodegradability according to ISO 14855

(Dr. Zechmann)
Staatlich geprüfte und zugelassene Lebensmittel-chemikerin

(Dr. Zang)
Geo-ecologist, Head of Compostability Testing Department

Der Bericht bezieht sich nur auf die hier beschriebenen Proben. Informationen und statistische Daten zum Ergebnis sind auf Anfrage erhältlich.

DAkkS
Deutsche Akkreditierungsstelle
D-PL-14160-01-01
D-PL-14160-01-02

Sample material

The following sample material was at hand:

sample 1: **Polymer- und Gold-beschichtete Cellulose-Di-Acetat Folie (eingegossen in Gelatine)**

Biodegradability test at ambient temperature

Examination period: 15 July 2019 to 17 October 2019

Aerobic biodegradability was tested according to ISO 14855-1:2012-12 (*'Determination of the ultimate aerobic biodegradability of plastic materials under controlled composting conditions - Method by analysis of evolved carbon dioxide - Part 1: General method'*).

The test was carried out using a respirometer system with 9 glass bioreactors (volume: 2.8 l) containing equal amounts of a compost inoculum (tab. 2). Three bioreactors each served for the incubation of the sample material (original form) and a reference material (microcellulose, particle size: 20 µm) (tab. 1) as well of the sole inoculum ('blanks'). The bioreactors were placed in a thermostatic chamber (incubation temperature: **25 °C**) and continuously flushed with ambient air. Carbon dioxide and oxygen concentration, humidity, pressure, chamber and analyzer temperature were consecutively measured in ambient air (fig. 1) and exhaust air of the bioreactors (fig. 2-4). Oxygen concentrations of > 10 % (vol.) were ensured by constant adjustment of air flow rate. In order to keep C/N-ratios comparable (target value: 25), respective amounts of urea were added to every bioreactor after 1 week (50 % of total amount) and after 3 and 6 weeks (25 % each) of incubation.

CO_2 production rate and cumulated CO_2 production were calculated for every measurement date using ideal gas law. Net CO_2 production was determined by subtraction of CO_2 production in the blanks from gross CO_2 production in sample and reference bioreactors (tab. 3). *Absolute biodegradation* in the considered time span was calculated from cumulated net CO_2 production relative to the amount of CO_2 that could theoretically be produced by the sample or reference material ('$ThCO_2$', tab. 1). Biodegradation of the test material was additionally expressed in relative terms to the reference material (*relative biodegradation*).

After a maximum test duration of 6 months, biodegradation of the test material must exceed 90 % in absolute terms or, alternatively, 90 % of the reference material.

Tab. 1: Characterization and input amount of sample and reference material

parameter	reference	sample 1
TOC[1] [% DW] (DIN EN 13137)	41.8	40.4[2]
absolute input amount per bioreactor [g DW]	31.1	50.2
$ThCO_2$ [g]	47.6	74.4

[1]analysis subcontracted to CRB Analyse Service GmbH
[2]TOC of sample 2 was detected with material dried at 25 °C (35.6 %). Dry weight- based TOC was calculated based on dry content at 25 °C and 105 °C

Tab. 2: Characterization and input amount of the inoculum

type and composition	compost from artificial biowaste according to ISO 16929 (age: 12-14 weeks), mixed with sand and vermiculite at a ratio of 7:20:5 [g DW]
humidity [% OS] (DIN 38409-H1:1987-01*)	60
volatile solids [% DW] (DIN 38409-H1:1987-01*)	28.6
total N[1] [g/kg DW] (DIN EN 25663*)	4.7
volatile fatty acids [mg HAc/kg OS] (MBK, III. C 3)	224
pH (ISO 10390:2005-12)	7.59
absolute input amount per bioreactor [g DW]	252
thereof: organic dry matter [g]	72

[1]before addition of urea

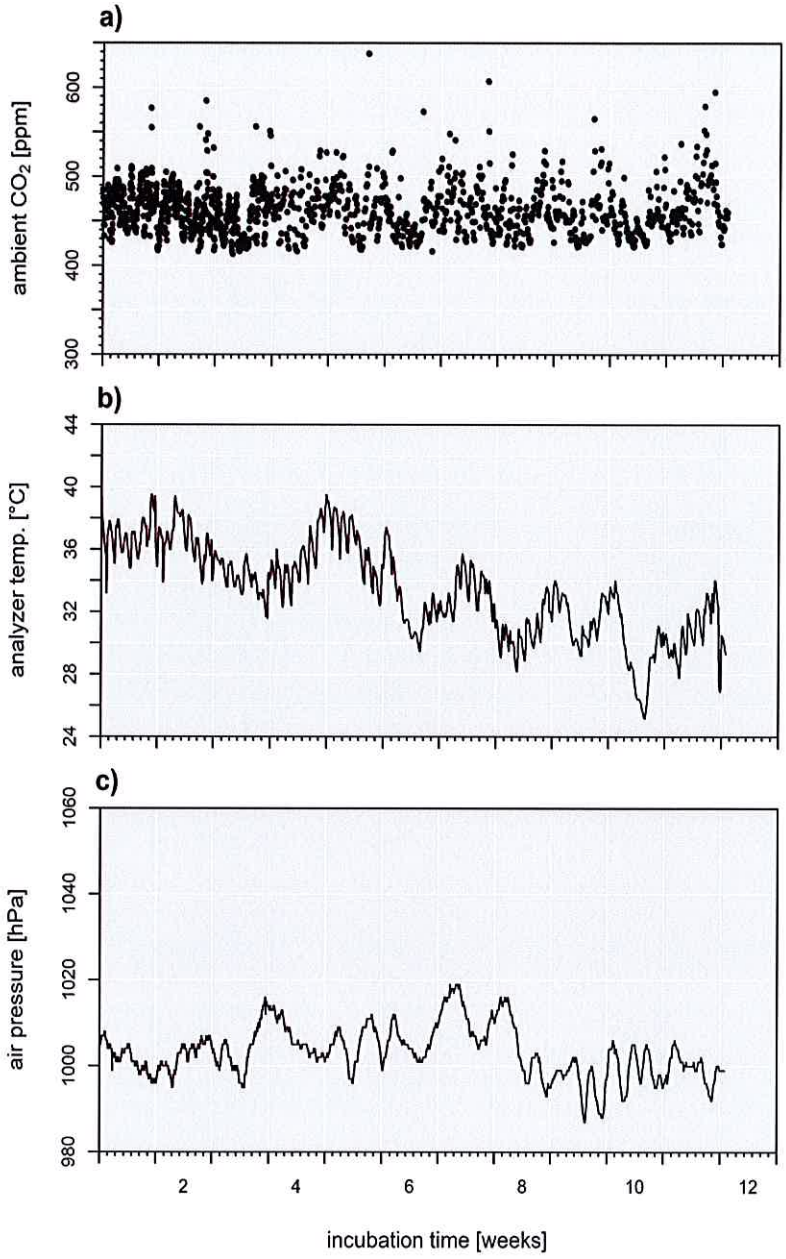

Fig. 1: Time course of ambient CO_2 concentration (a), analyzer temperature (b) and air pressure (c) during incubation

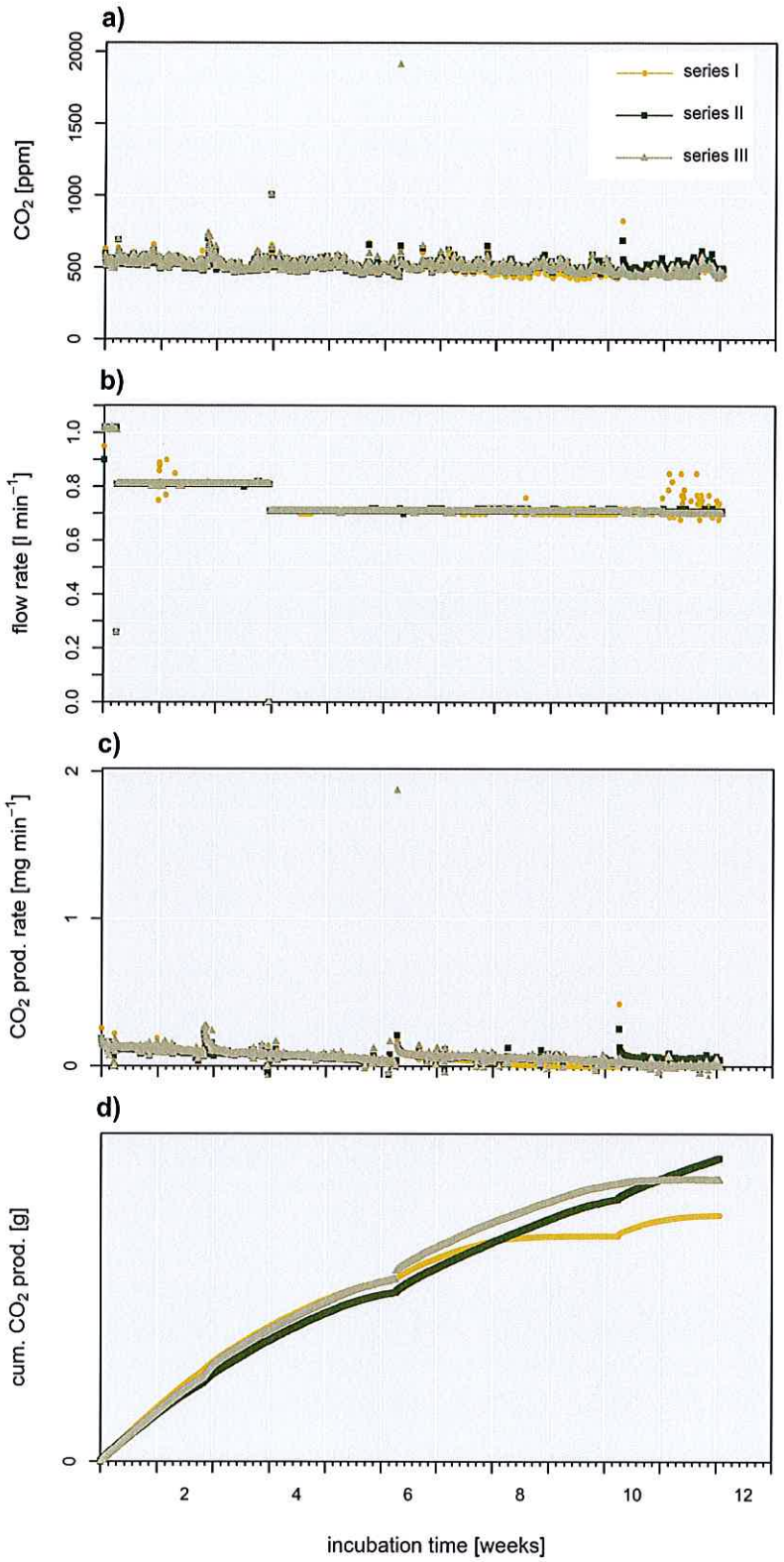

Fig. 2: Time course of measured CO_2 concentration (a), air flow rate (b), calculated gross CO_2 production rate (c) and cumulated gross CO_2 production (d) during incubation for blank bioreactors

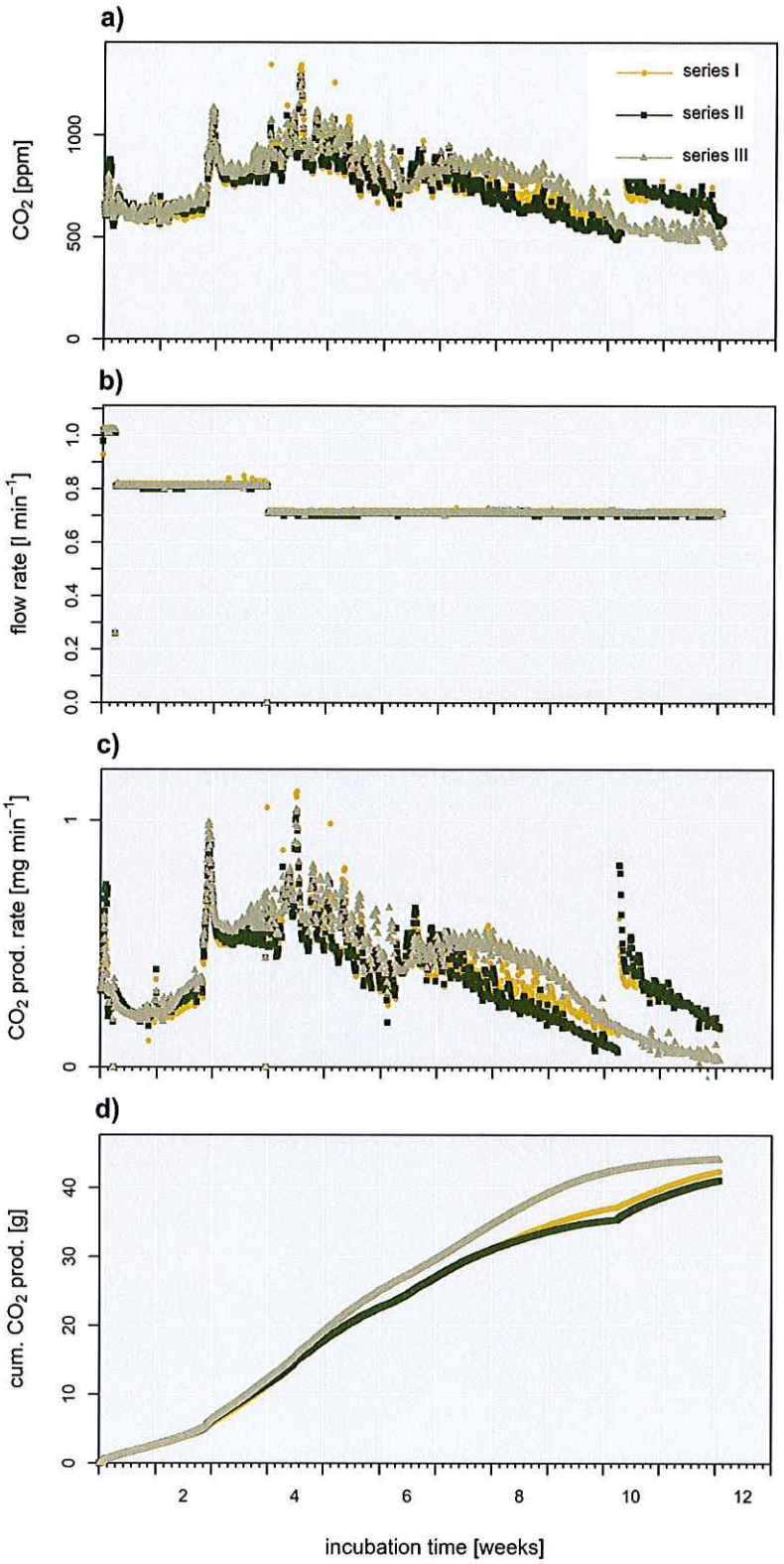

Fig. 3: Time course of measured CO_2 concentration (a), air flow rate (b), calculated gross CO_2 production rate (c) and cumulated gross CO_2 production (d) during incubation for reference bioreactors

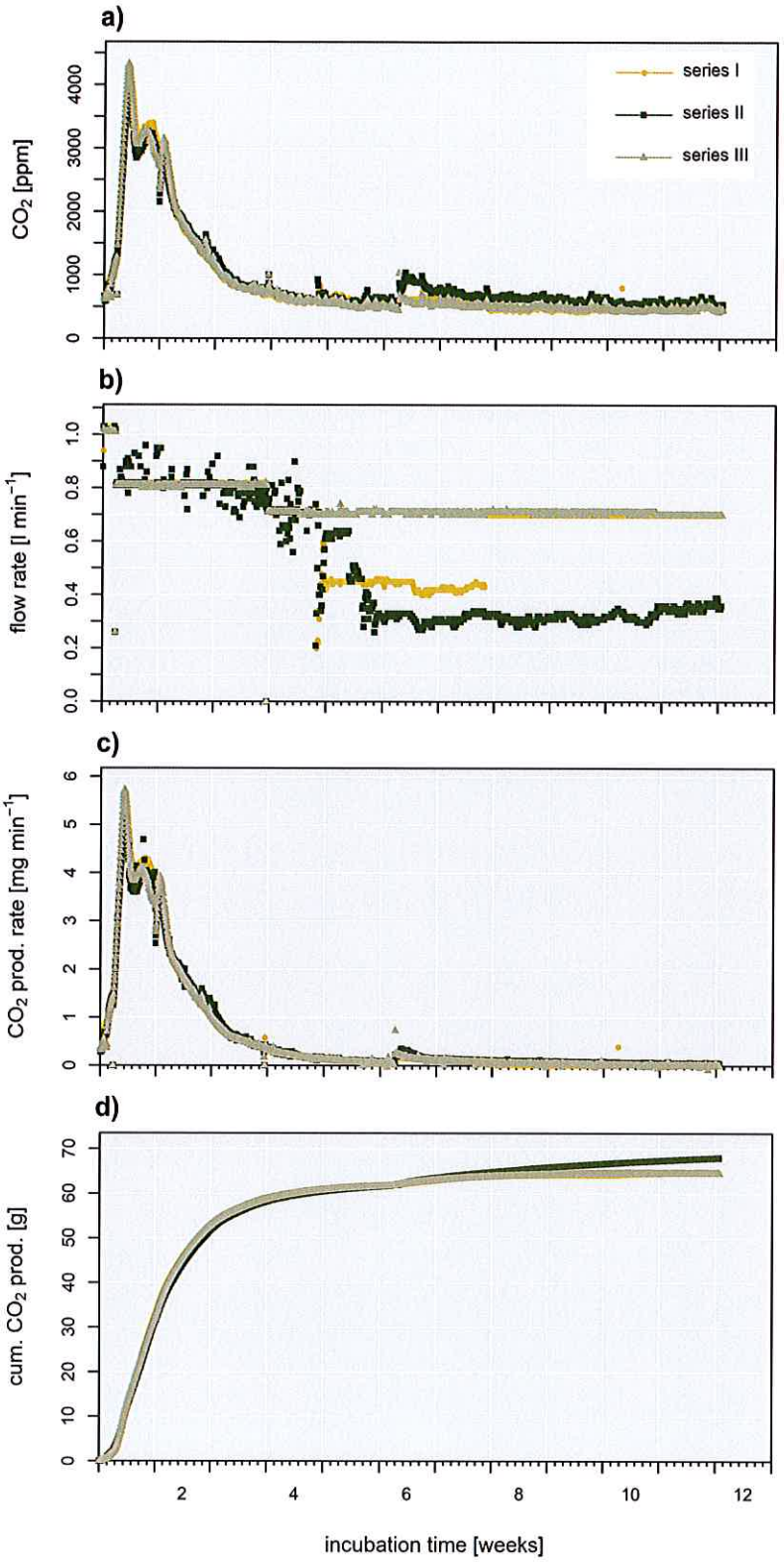

Fig. 4: Time course of measured CO_2 concentration (a), air flow rate (b), calculated gross CO_2 production rate (c) and cumulated gross CO_2 production (d) during incubation for sample bioreactors

Tab. 3: Activity of the inoculum after 10 days and absolute and relative biodegradation after end of the test

parameter	series	blank	reference	sample 1
absolute CO_2 production after 10 days [g]	I	1.9		
	II	1.6		
	III	1.7		
	mean	*1.7*		
relative CO_2 production after 10 days [mg/g organic dry matter]	*mean*	*24*		
CO_2 production after 45 days [g]	I	5.3	28.8	
	II	5.1	29.0	
	III	5.6	31.9	
	mean	*5.3*	*29.9*	
net CO_2 production after 45 days [g]	*mean*		*24.6*	
absolute biodegradation after 45 days [%]	*mean*		*51.7*	
CO_2 production during incubation period [g]	I	6.1	42.4	64.7
	II	7.6	41.1	68.1
	III	7.0	44.1	64.5
	mean	*6.9*	*42.6*	*65.8*
net CO_2 production during incubation period [g]	I		35.5	57.8
	II		34.2	61.1
	III		37.2	57.6
	mean		*35.7*	*58.9*
absolute biodegradation [%]	I		74.6	77.7
	II		71.9	82.2
	III		78.2	77.5
	mean		***74.9***	***79.1***
	CV [%]		*4.2*	*3.4*
biodegradation relative to reference [%]	***mean***			***105.6***

' < ' lower than limit of quantification
' OS ' original substance
' DW ' dry weight
' CV ' coefficient of variation
' MBK ' Methods Book for the Analysis of Compost (Methodenbuch zur Analyse organischer Düngemittel, Bodenverbesserungsmittel und Substrate), Bundesgütegemeinschaft Kompost e.V., Cologne, Germany 2006

The accreditation applies to the methods marked with * in the test report (Register no.D-PL-14160-01-01 and D-PL-14160-01-02). ISEGA is a DIN CERTCO-approved testing laboratory (Register no. PL045).

END OF REPORT