by macro-organisms such as mealworms and greater wax moth larvae: technological application potential

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Current Biology

Volume 27, Issue 8, 24 April 2017, Pages R292-R293

CellPress

Correspondence

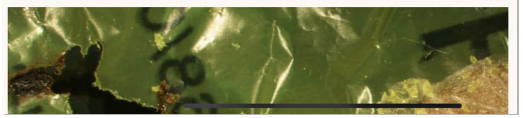
Polyethylene bio-degradation by caterpillars of the wax moth *Galleria mellonella*

Paolo Bombelli [1], Christopher J. Howe [1] ✉, Federica Bertocchini [2, 3] ✉

Plastic-eating bugs? It's a great story – but there's a sting in the tail

Philip Ball

Breeding wax moth caterpillars to devour our waste sounds good. But they would attack bee colonies too, and ultimately put crops at risk



The Guardian Tue 25 Apr 2017

The New York Times

A Very Hungry Caterpillar Eats Plastic Bags, Researchers Say

Scientists have discovered that a caterpillar used for fishing bait may hold the key to breaking down plastics. Cesar Hernandez/CSIC, via Agence France-Presse — Getty Images

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Holes in plastic bags containing wax moth (*Galleria mellonella*) caterpillars tipped off researchers that the creatures can break down plastic. César Hernández/CSIC

ANIMAL BEHAVIOUR · 24 APRIL 2017

This caterpillar can digest plastic

Wax-moth larvae could inspire biotechnological methods for degrading plastic.

SCIENTIFIC AMERICAN

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CHEMISTRY

Plastic-Eating Worms Could Inspire Waste-Degrading Tools

Wax moth larvae can consume and degrade polyethylene at an impressive rate

By Matthew Sedacca on August 1, 2017

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Science & Environment

Plastic-eating caterpillar could munch waste, scientists say

By Helen Briggs
BBC News

24 April 2017

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...s van de grote wasmot eet ...stic (zakken) op

De rups van de grote wasmot, een soort nachtvlinder, blijkt plastic te eten en dat aan een hoog tempo. Daarmee is natuurlijk de gigantische plasticberg nog niet weggewerkt, maar het schept hoop en opent vooral perspectieven. Het diertje breekt onder meer polyethyleen af. En dat wordt vooral gebruikt om plastic winkeltassen te maken.

Sandra Cardoen
di 25 apr 2017 10:38

Plastic-etende rups ontdekt: hoopgevend, maar het plasticprobleem blijft

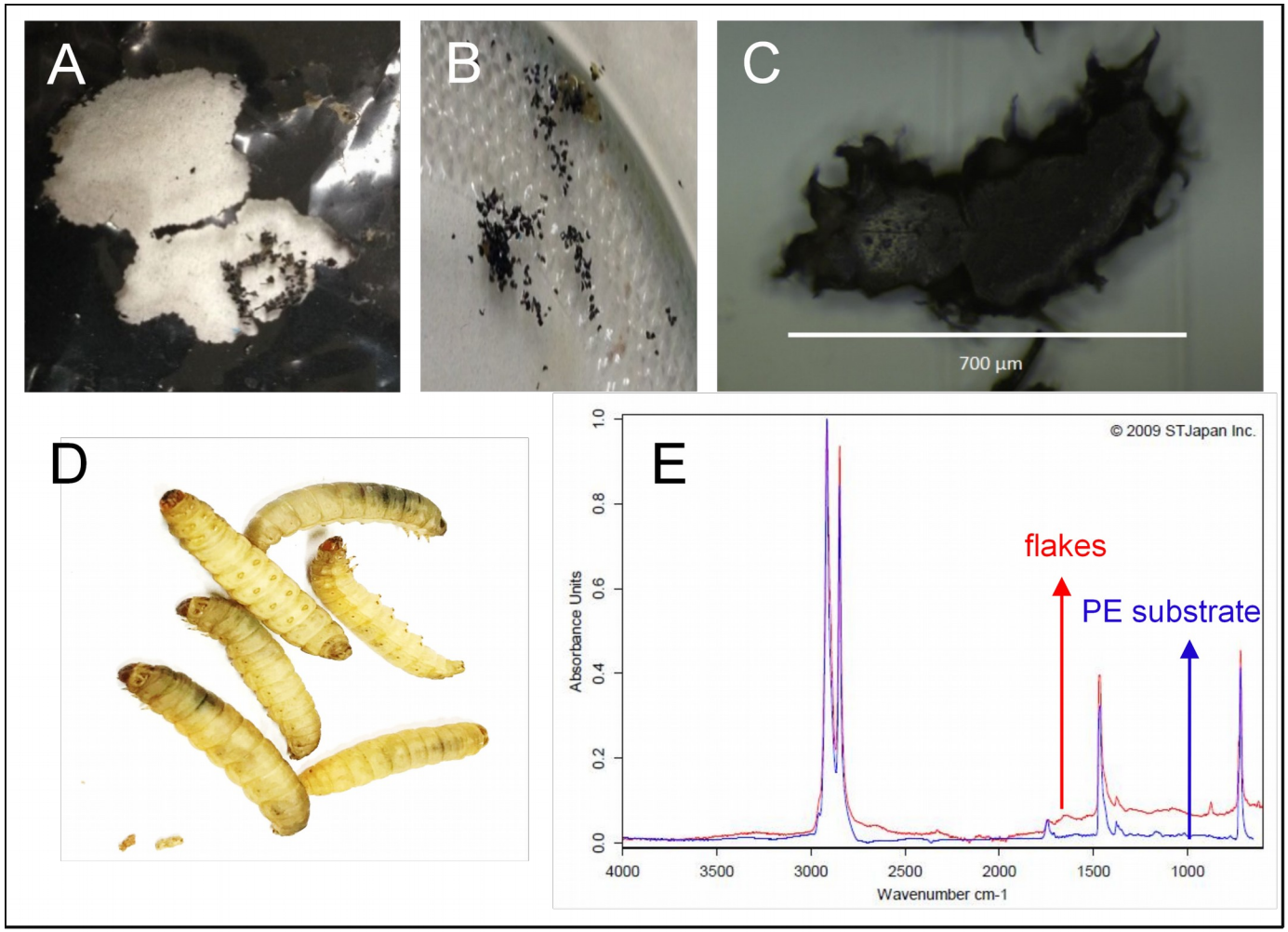
Plastic is een hardnekkig probleem. We produceren jaarlijks miljarden kilo's afval, maar een oplossing voor de vervuiling lijkt ver weg. Tot nu: wetenschappers stuitten toevallig op een rups die op relatief hoge snelheid plastic kan opeten én verteren. Gisteren verschenen de resultaten in het wetenschappelijke tijdschrift *Current Biology*.

Anne ter Rele 25-04-17, 18:54

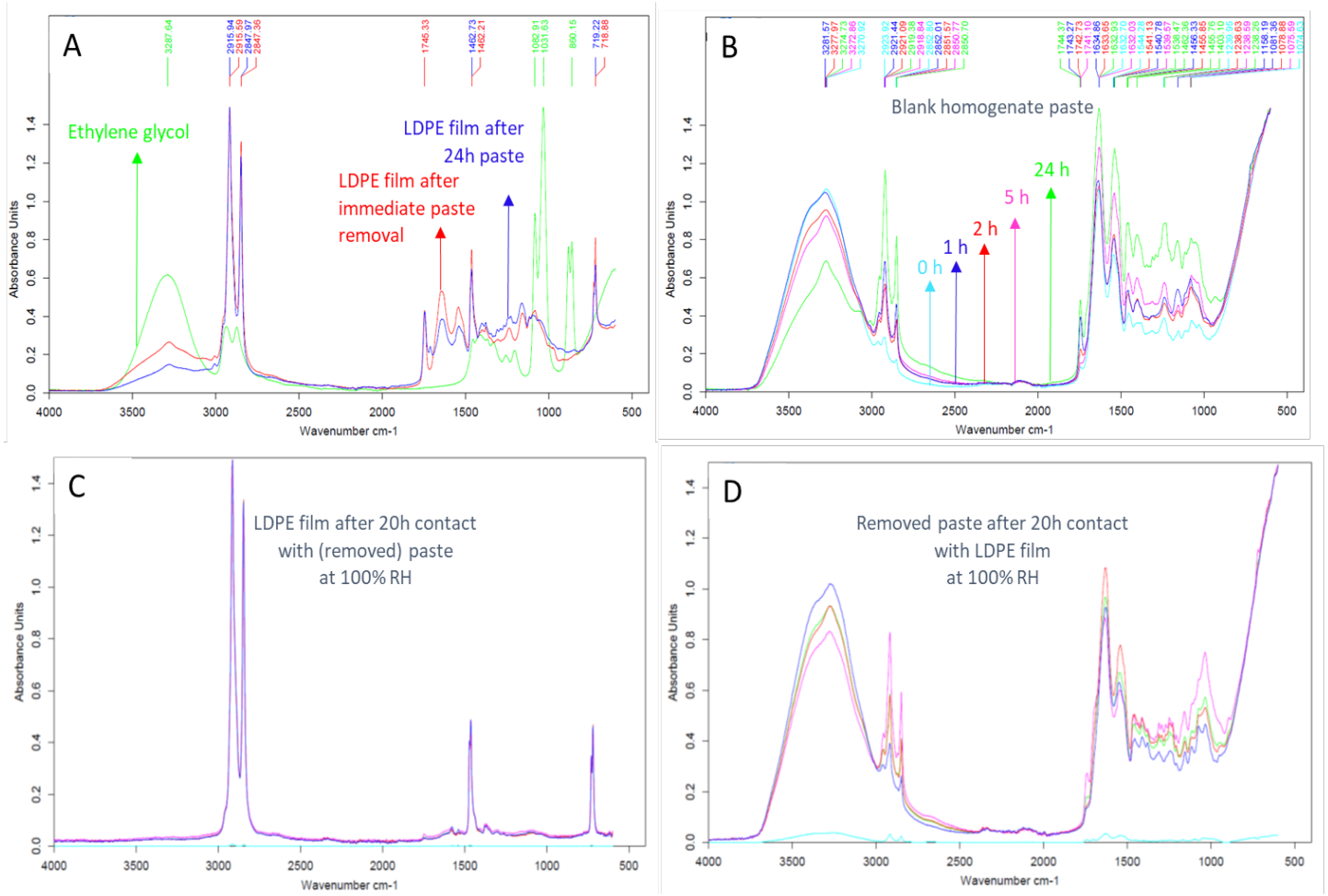
Experiments

Format	Species	Substrate	Time	Experiment code
Live larvae	Galleria mellonella	Loosely folded cling film (LDPE)	17 h	$live_{GWM}\_1$
		Loosely folded cling film (LDPE)	89 h	$live_{GWM}\_2$
		Folded layers cling film (LDPE)	96 h	$live_{GWM}\_3$
		Loosely folded black bag (LDPE)	216 h	$live_{GWM}\_4$
	Tenebrio molitor	Loosely folded cling film (LDPE)	38 days	$live_{MW}\_1$
		Commercial fruit bag (LDPE)	38 days	$live_{MW}\_2$
		None (blank)	38 days	$live_{MW}\_3$
		Bran	38 days	$live_{MW}\_4$
Homogenate	Galleria mellonella	Cling film (LDPE)	48 h	$paste_{GWM}\_1$
		Cling film (LDPE) at 100 % RH	20 h	$paste_{GWM}\_2$
		Cling film (LDPE) and blank paste	0 – 120 h	$paste_{GWM}\_3$
		Liquid paraffin at 100 % RH	14 days	$paste_{GWM}$_paraffin
		Polystyrene (PS) powder at 100 % RH	14 days	$paste_{GWM}$_PS
	Tenebrio	Liquid paraffin at 100 % RH	14 days	$paste_{MW}$_paraffi

Live larvae with polyethylene



Degradation by biomass paste?

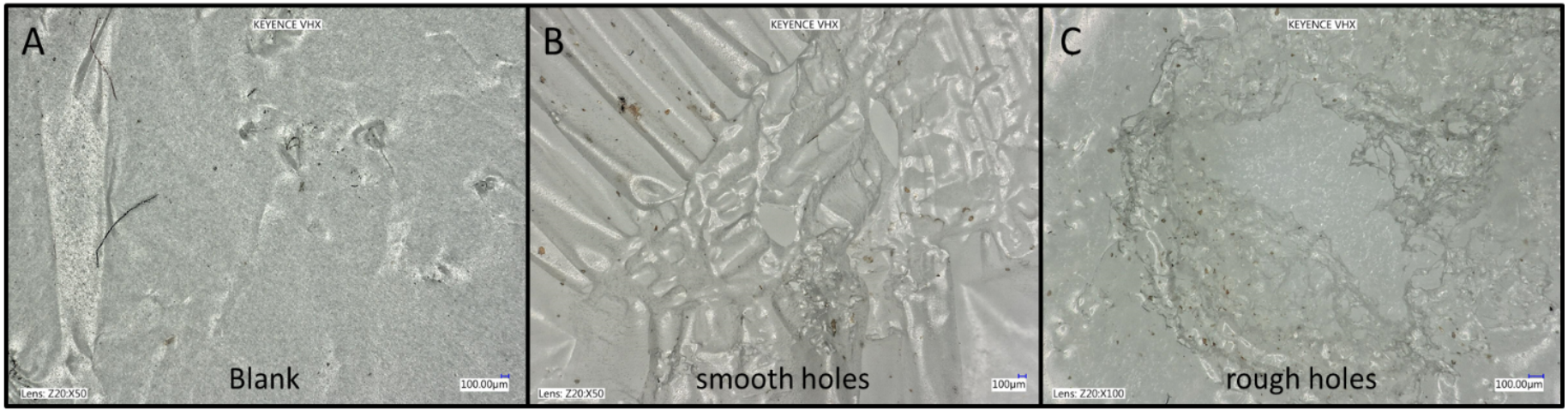


No gravimetric changes

No glycol (confirming *Weber et al.* 2017)

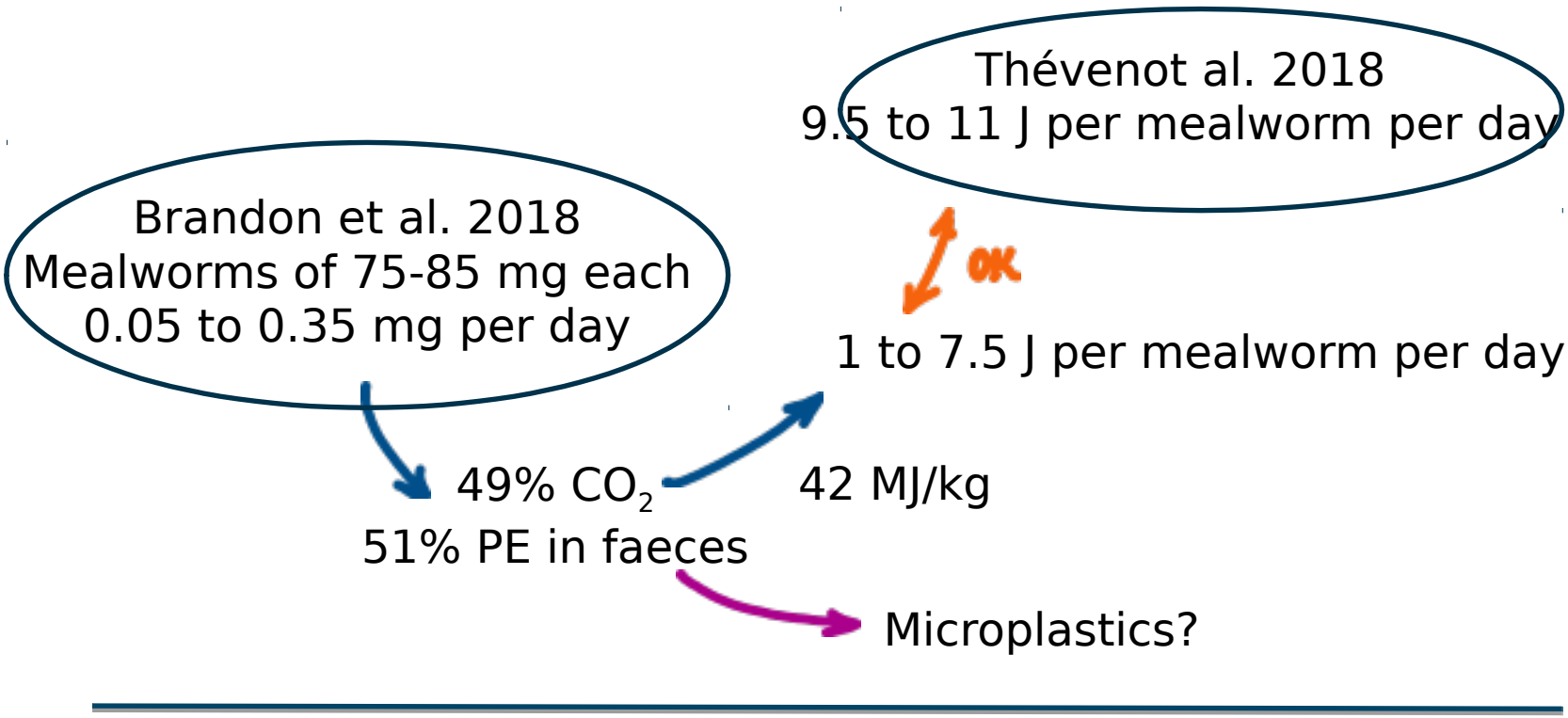
Weber, C., Pusch, S., Opatz, T. Current Biol 27, R731–45 (2017)

How do they do it?



Food for thought...

Technology potential



0.35 mg PE per day (Brandon et al.)
to 0.45 mg (calculated, Thévenot et al.)

Thévenot, A., Rivera, J.L., Wilfart, A., Maillard, F., Hassouna, M., Senga-Kiesse, T., Le Féon, S., Aubin, J. J Clean Prod 176, 1260-1267 (2018)
Brandon, A.M., Gao, S.H., Tian, R., Ning, D., Yang, S.S., Zhou, J., Wu, W.M., Criddle, C.S. Env Sci Technol 52, 6526-6532 (2018)

Technology potential

0.35 mg PE per day (Brandon et al.)
to 0.45 mg (calculated, Thévenot et al.)

Zheng et al. (2013):
mealworms in 76 days to 176 mg

Functional unit:
complete consumption of 1 tonne of PE film (without additional food) by 35-day old mealworms in an additional 32 days

Oonincxx & de Boer (2012):
55 mWh of grid electricity
240 mWh of natural gas
0.22 L of water per mealworm

5.5 to 7.1 tonnes of mealworms required

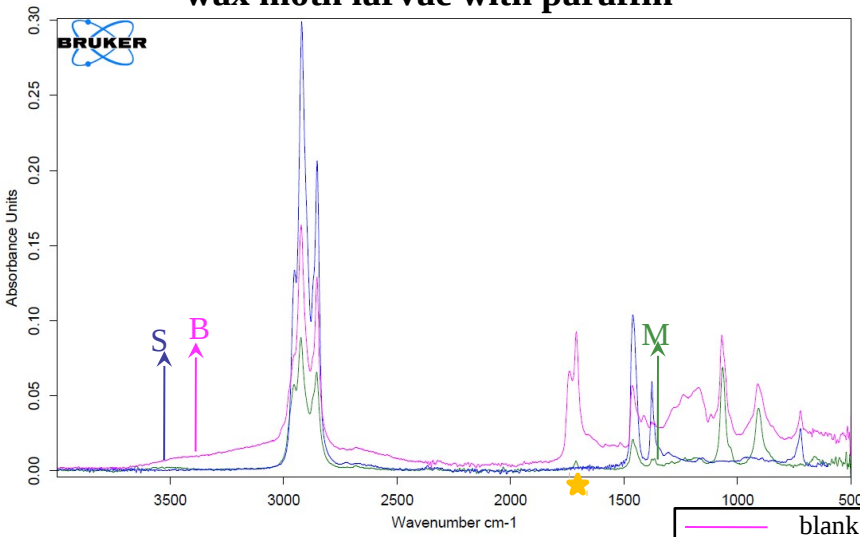
Biomass growth?
Valorization of frass?
Revenue from biodiesel?

Electricity 290 EUR to 370 EUR
Natural gas 500 EUR to 642 EUR
790 EUR to 1112 EUR per tonne of PE treated

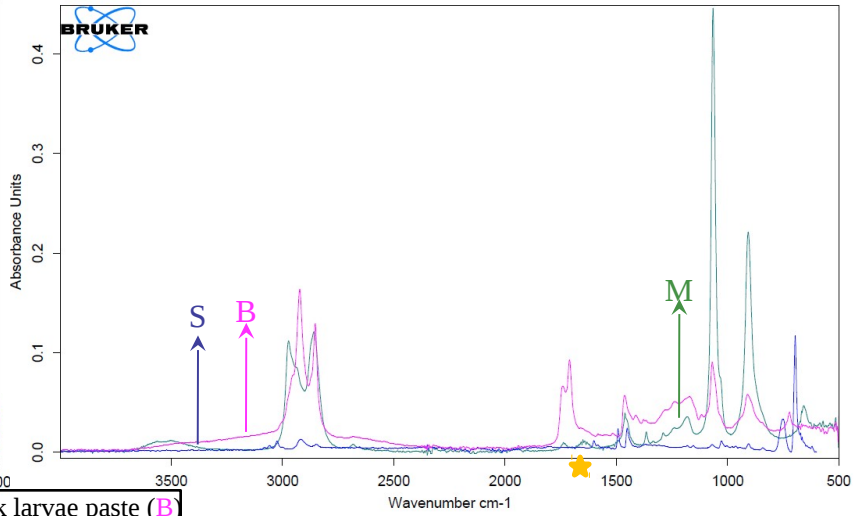
Zheng, L., Hou, Y., Li, W., Yang, S., Li, Q., Yu, Z. Appl Energ 101, 808-814 (2013).
Oonincxx, D.G.A.B., de Boer, I.J.M. PLOS One 7(12), e51145 (2012)

Yet… there may be value

paste$_{GWM}$_paraffin
wax moth larvae with paraffin

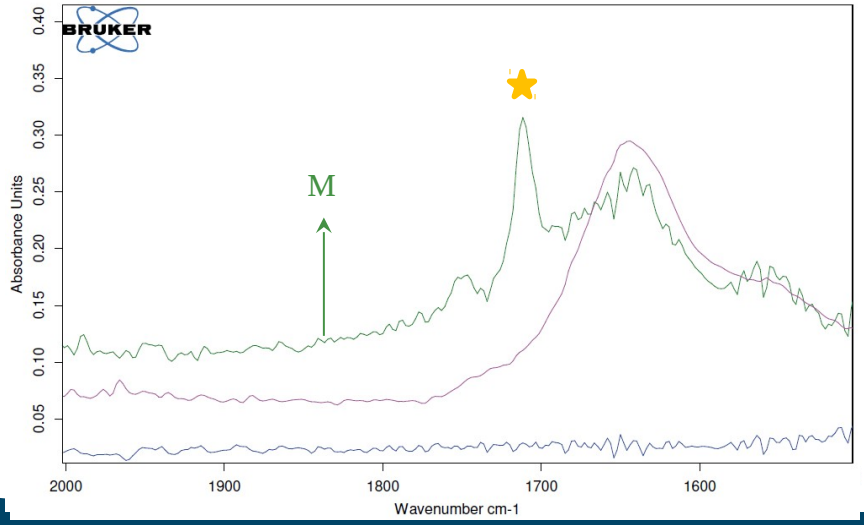


paste$_{GWM}$_PS
wax moth larvae with polystyrene

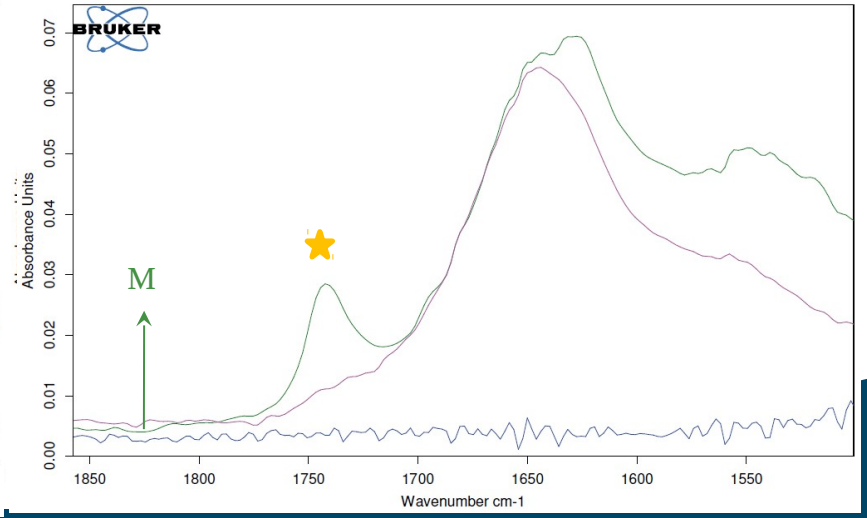


blank larvae paste (B)
blank substrate (S)
treated mixture (M)

paste$_{MW}$_paraffin
mealworms with paraffin



paste$_{MW}$_PS
mealworms with polystyrene



Conclusions

- Destruction (degradation) of PE is not OK, especially not without energetic valorization
- No feasible remediation technology
  - Preference for other nutrition (even cannibalism)
  - Ubiquity and abundance issues
  - Microplastics

- Fundamental biological insights are interesting
- Indications of paraffin functionalization: promising for biochemical process?

Invitation for collaboration

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