

# InnoCircle recycled filaments: high tech and improved sustainability merge!



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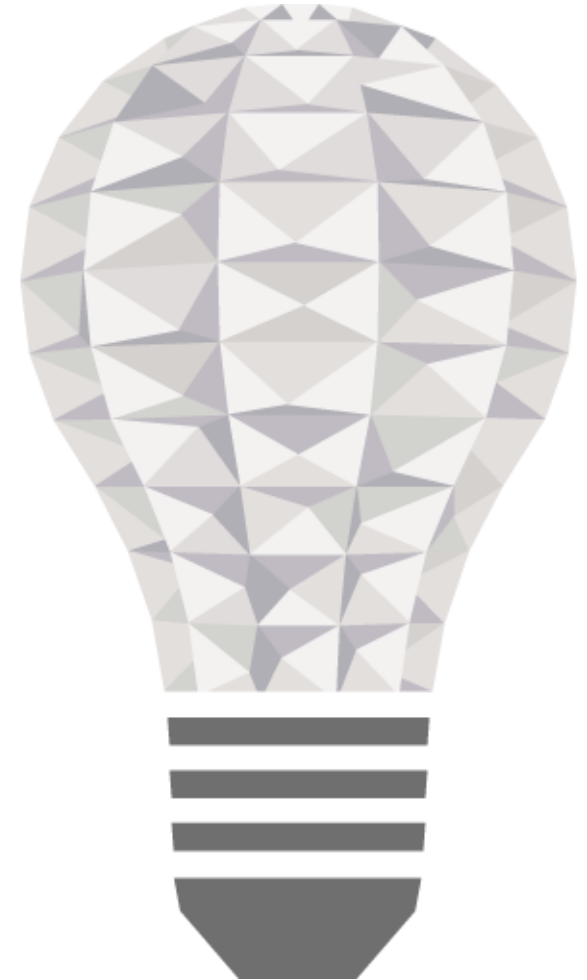




*"Daddy, we need to take care of the earth!"*

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## Company profiles

### Innofil3D

- Part of Applied Polymer Institute, NL based
- Originated from R&D Diolen Fibers, formerly Akzo Nobel
- In-depth polymer science and manufacturing expertise
- 18 FTE's
- Extended laboratory and manufacturing facilities
- Develops, manufactures and sells monofilament

### CiorC

- Focuses on the development of recycled filaments
- 20 years background in materials sciences, sustainability and complex business development

***Innofil3D & CiorC joint competences:  
high-tech recycled filaments developed fast***

Innofil<sup>3D</sup>



## Why printing circularly? (1/3)

In Europe (2012):

- **We consumed: 45.9 million tons of plastics**
- **We disposed: 25 million tons of plastics, of which we**
- **We burnt: 9.0 million tons of plastics**
- **We landfilled: 8.4 million tons of plastics**
- **We recycled: 6.6 million tons of plastics**

**We recycled only 14.3% of our total European consumption!**

\*Source: PlasticsEurope, numbers valid for EU27 in 2012



## Why printing circularly? (2/3)

### Carbon footprint of plastics

Virgin plastics made from oil: 6 KG CO<sub>2</sub> emissions per KG plastic

Recycled plastics: 3 – 5 KG CO<sub>2</sub> emissions per KG plastic

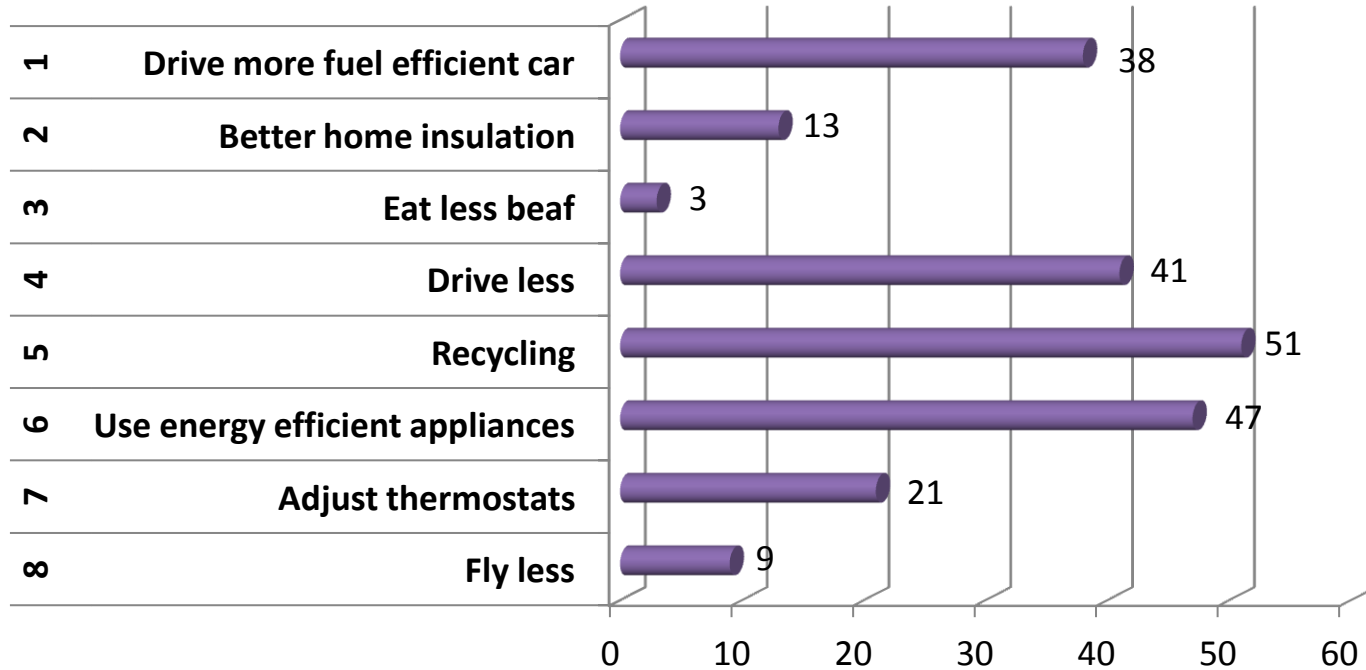
**Recycling can save up to 50% in CO<sub>2</sub> emissions!**

Source: <http://timeforchange.org/plastic-bags-and-plastic-bottles-CO2-emissions>

# Why printing circularly? (3/3)

Ranking by actual effectiveness

Perceived effectiveness



(%) of respondents who ranked change as 1 of 3 best approaches to reduce global warming

**Recycling is effective to reduce global warming, most people keen to enable recycling**



**We need to better than this!**

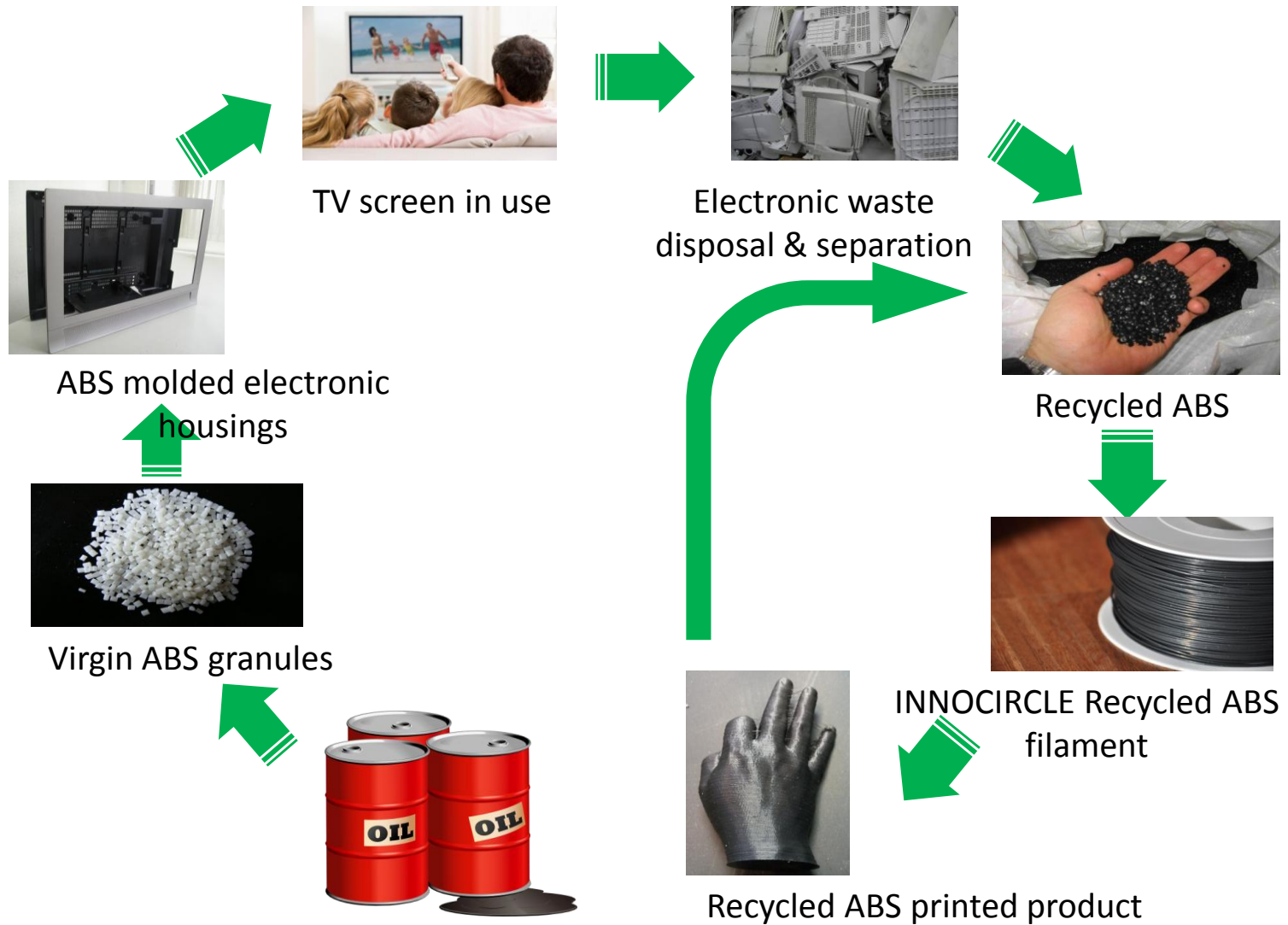


How could we print circularly?





# The Plastic Electronics Waste Loop



**Recycling plastics: not an easy job!**



**Contamination: food waste, metals wood, fibers, particularly in post consumer scrap**



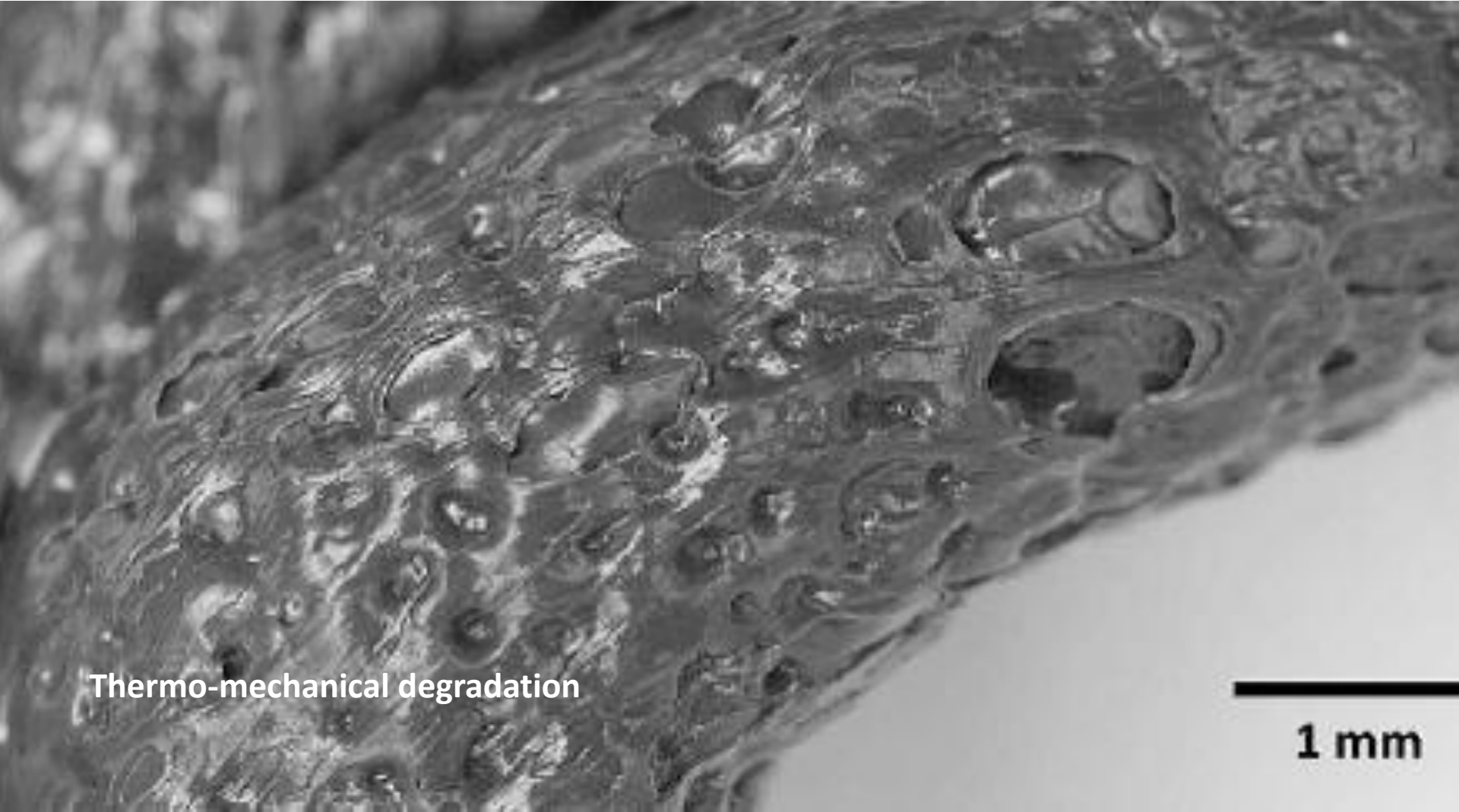


Recycling plastics: not an easy job!

*Impurities in plastics: pigments, flame retardants, additives (flow modifiers, UV stabilizers)*



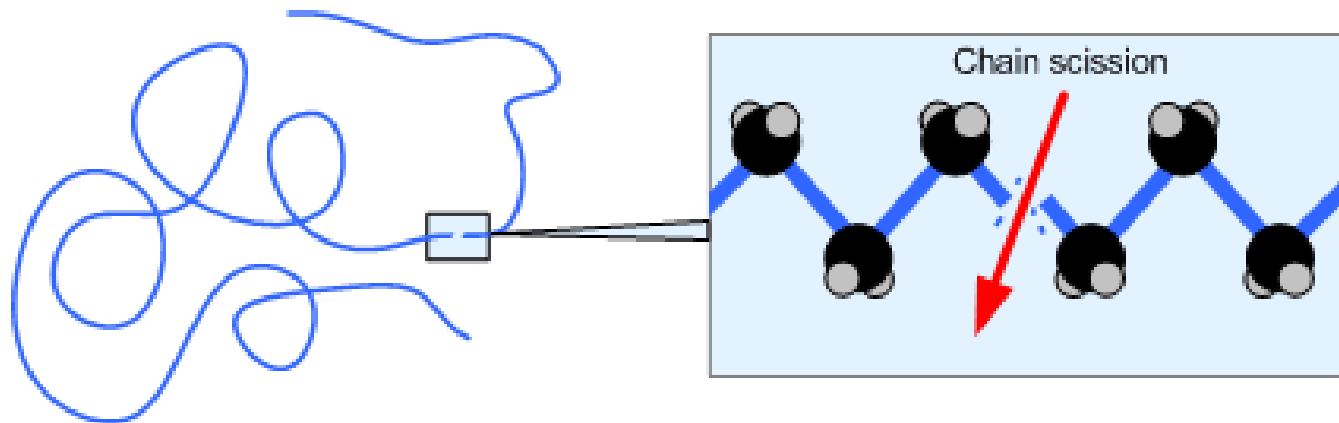
# Recycling plastics: not an easy job!



Thermo-mechanical degradation

1 mm

**During product life cycles, the polymer structure degrades!**



***Polymer chains shorten, so functional properties reduce!***



# Reprocessing and recycling degrades ABS impact properties up to 30%!

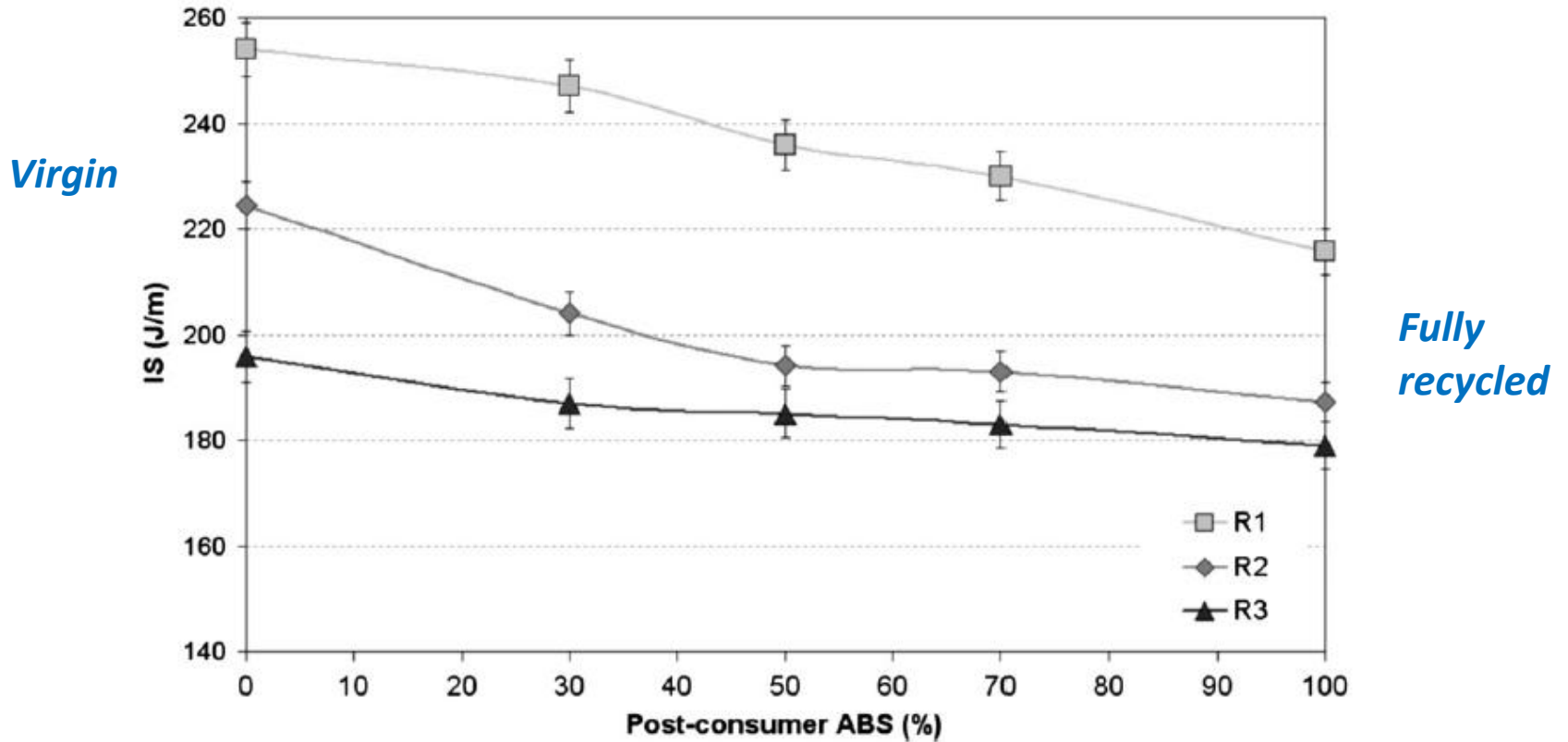


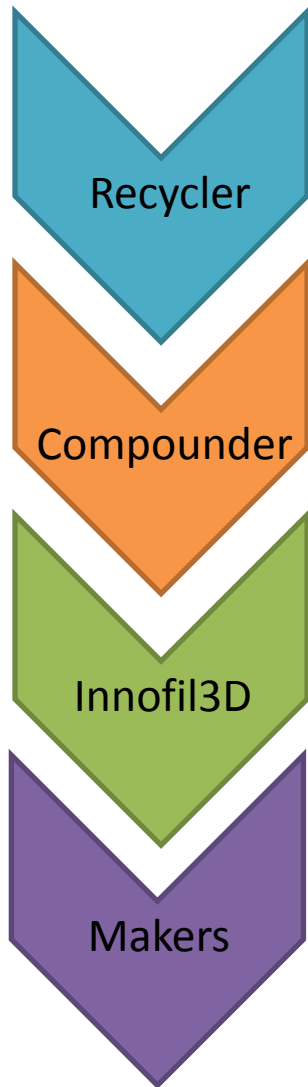
Fig. 10. Impact strength (IS) of the blends reprocessed up to three times as a function of the amount of pc-ABS.

*Similar degradation trends in tensile strength and elongation after break observed*





# Towards the **right** recycled FDM filaments = teaming up in the value chain



Select the right sources & color  
product consistency



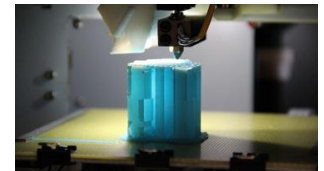
Detect presence hazardous components  
Boost the mechanical and flow properties



Set right filament processing  
window



Improve the printing performance



## “Boosted” recycled ABS compared a general purpose ABS made from oil

	Recycled ABS (InnoCircle ABS)	Virgin ABS (Magnum 3453*)	Unit	Test Method
<b>Physical properties</b>				
Density	1.05	1.05	g/cm <sup>3</sup>	ISO 1183
<b>Rheological properties</b>				
MFI (220°C / 10.0 kg)	22	15	g/10 min	ISO 1133
MFI (230°C / 3.8 kg)	6	N.A.	g/10 min	ISO 1133
<b>Mechanical properties</b>				
Flexural Modulus (23°C)	2100	2280	MPa	ISO 78
Tensile Stress at Yield (23°C)	40	45	MPa	ISO 527-2/50
Notched Izod Impact Strength (23°C)	10	19	kJ/m <sup>2</sup>	ISO 180/1A
<b>Thermal properties</b>				
HDT A (1.8 MPa)	80	100	°C	ISO 75-1 A
Vicat A	104	N.A.	°C	ISO 306
Vicat B	95	97	°C	ISO 306

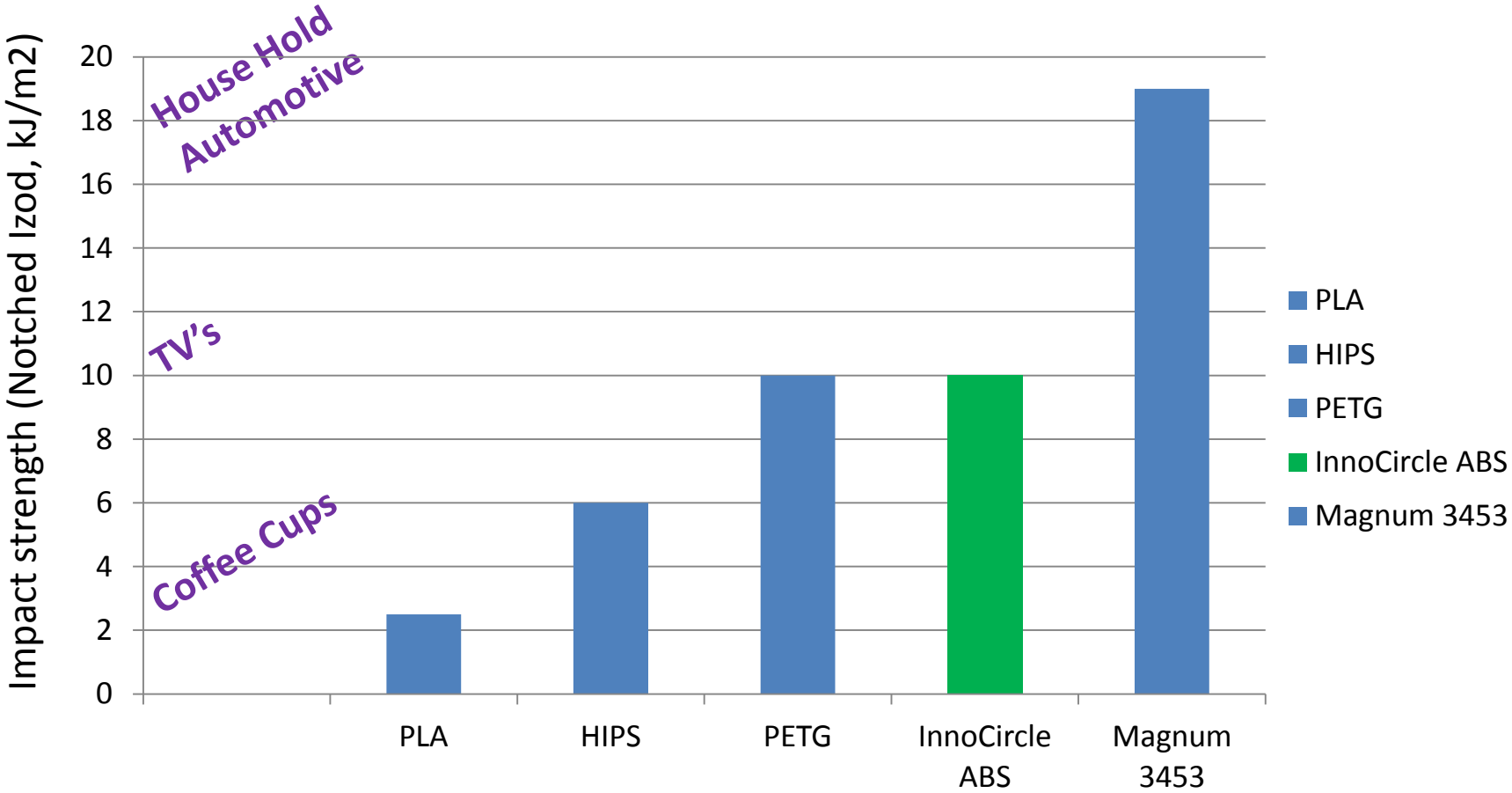
**InnoCircle ABS shows similar performance than Magnum 3453, expect Impact Strength & Heat Deflection Temperature**

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\* Source: [www.matweb.com](http://www.matweb.com)

# But... InnoCircle ABS impact strength benchmarks fairly well with other virgin widely applied filament materials





## Apply recycled plastic responsibly!

### ***RoHS EC2011/65/EU***

Restriction of certain **Hazardous Substances** in electrical and electronic equipment, such as:

Pb, Hg, Cd, Cr, polybrominated biphenyls (PBB) & polybrominated diphenylethers (PBDE)

### ***REACH EC 2006/1907***

Registration, **E**valuation, **A**uthorisation and restriction of **C**hemicals.

Aims to improve the **protection of human health** and the **environment** through the better and earlier **identification** of the intrinsic properties of **chemical substances**.

***InnoCircle filaments are REACH and RoHS compliant!***



# Improving the printing performance

Changing the existing PLA formulation by carefully selecting additives results in a drastically improved printing behavior.

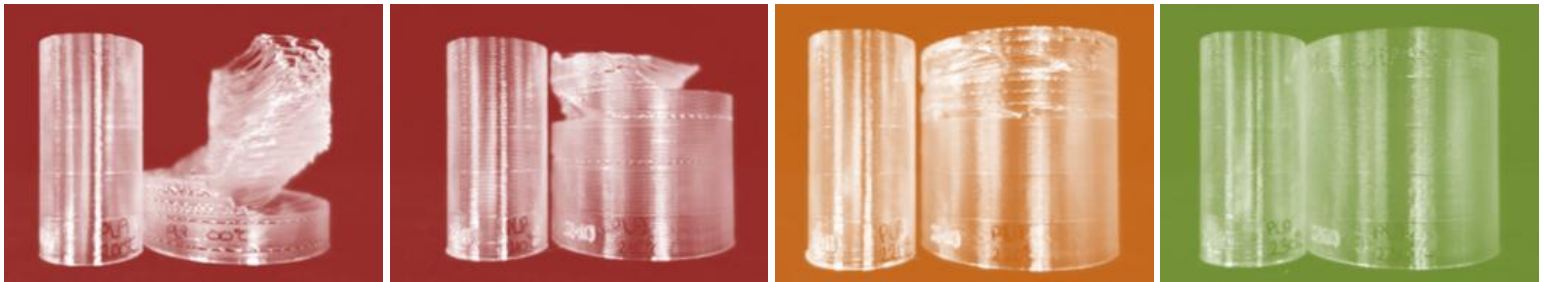
200 °C

210 °C

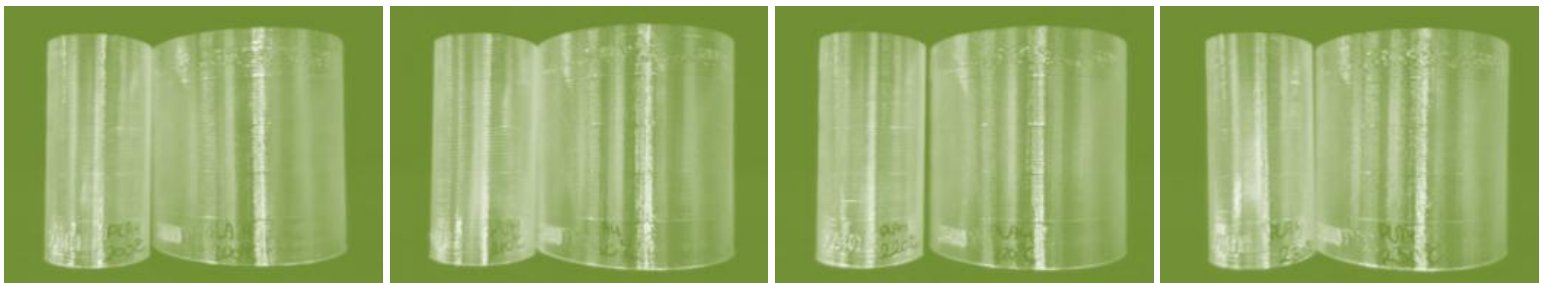
220 °C

230 °C

No additives



With additives



# The InnoCircle Benefits

- Good and consistent *material properties*
- Excellent *printing performance*, similar like virgin filament
- *Sustainable*: Save up to 50% in CO<sub>2</sub> emissions in comparison with virgin filaments
- *Responsible*: REACH & RoHS compliant
- InnoCircle PLA available in 6 colors

InnoCircle® (Recycled materials)			Product codes		
Product number	Name	Net weight	1.75 mm	2.85 mm	Special feature
RPLA-6001	InnoCircle® rPLA Natural	750 grams	RPLA-6001a075	RPLA-6001b075	Recycled PLA
RABS-6101	InnoCircle® rABS Black	750 grams	RABS-6101a075	RABS-6101b075	Recycled ABS
PETR-0601	InnoCircle® rPET Natural	750 grams	PETR-0601a075	PETR-0601b075	Recycled PET







Round-up

# From Recycled To...

# InnoCircle ABS



In black only





# InnoCircle PET



In natural blue only

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# InnoCircle PLA



Available in 6 colors

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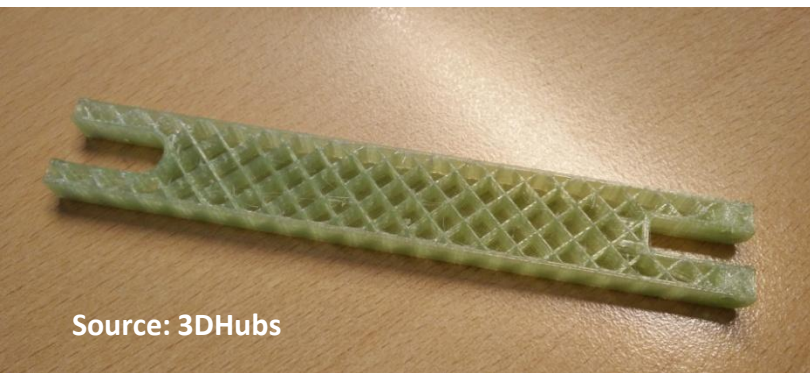


# From InnoCircle To...

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# Your imagination to make printed products sustainably!



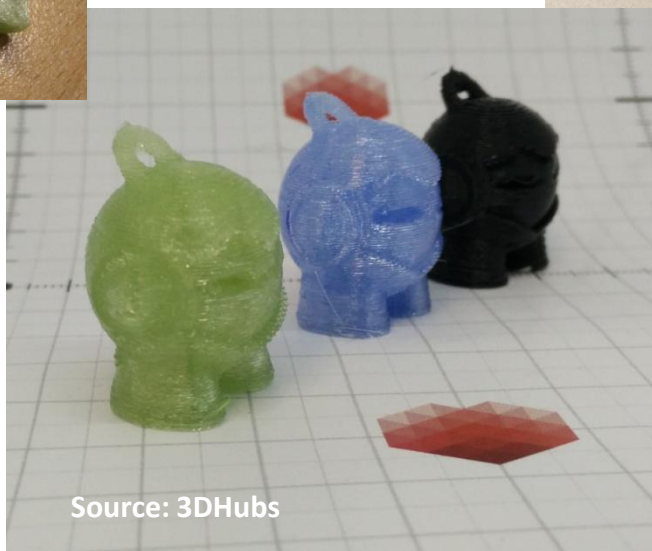
Source: 3DHubs



Source: Innofil3D



Source: iGO3D



Source: 3DHubs



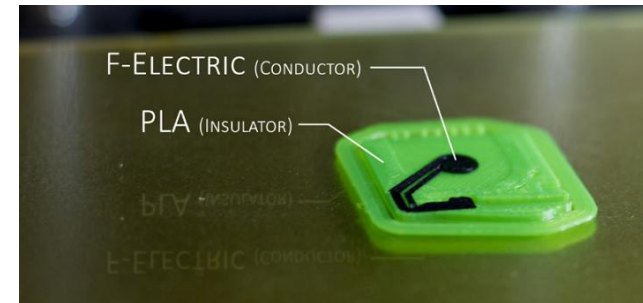
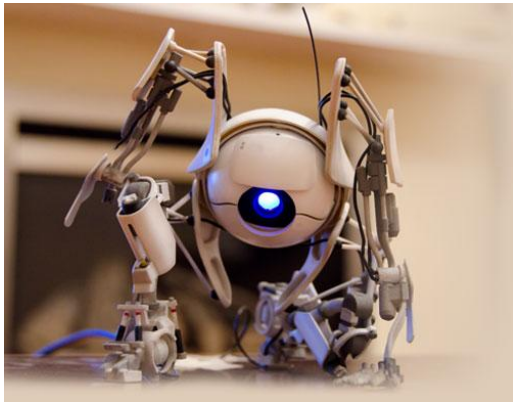
Source: 3Dprintingmagazine

*3DHubs: 'The only thing I'll say is that it was super easy to print with and that I think the results look awesome :)'*

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# InnoCircle is developing high performance **recycled** filaments



Do you have **green** high-tech project ideas? Contact us!



# Thank you for your attention!

Questions? Remarks? Visit our booth Hall 16, D87!



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## Annex 1. Recommended InnoCircle printer conditions

	Nozzle temperature	Heated bed temperature	Printing speed
InnoCircle PLA	210-230 °C	60-75 °C	40-80 mm/s
InnoCircle PET	220-250 °C	75-85 °C	40-80 mm/s
InnoCircle ABS	230-250 °C	80-90 °C	40-80 mm/s



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