

# Chemical Recycling of Mixed Plastic Waste Feedstock with Screw Pyrolysis Technology

Hans Leibold, Marco Tomasi Morgano, Frank Richter

Institute for Technical Chemistry





KIT - The Research University in the Helmholtz Association

# **Plastic waste in Germany 2017**





#### **Pyrolysis of plastic materials**







# **STYX Pyrolysis reactor**



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#### **Feedstock investigated**



Polyethylen/Polypropylen mixture	PE/PP
Post-consumer mixed plastic waste (model)	MPW
<ul> <li>AcryInitrile-Butadien-Polyamide</li> <li>Polycarbonate</li> <li>Polyamide</li> </ul>	ABS
Sorting residue	SR



#### **Pretreatment of feedstock**





#### Hot stage microscope data

- Swelling of specimen at the melting point
- Structure breakdown far above the melting point
- Breakdown depends on plastic type
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### **Pyrolysis PE/PP**

#### **Mass Balance**



### Analysis of the PE/PP pyrolysis products





- Valuable olefine fraction in the pyrolysis gas
- Hydrocarbons < C<sub>21</sub> in wax/ condensate product by GC
- Staged condensation of hydrocarbons can be optimized



#### **MPW -** Post-consumer plastic waste Mass and carbon partitioning





#### MPW + Ca(OH)<sub>2</sub>

- Products: Condensate, permanent gas, solids no wax
- Condensate contains about 1.0 wt.% water from sorption reactions
- Most of the aromatics are converted into coke
- HCl removal from vapors > 99.0 %
  - $\rightarrow$  Cl^-  $\,$  343 mg/kg in condensate
  - $\rightarrow$  HCl 225 mg/m<sup>3</sup> in pyrolysis gas (N<sub>2</sub>–free)

#### **ABS -** Mixed plastic waste Mass and carbon partitioning





Condensate > 66 wt.% on total input basis

- Carbon loss due to larger hydrocarbons in gas + very low concentration in solids
- Concentration Cl<sup>-</sup> in condensate < 150 mg/kg</li>
- Qualitative analysis of pollutants in gas indicates presence of HCI, HBr and HCN

#### MPW and ABS Plastic waste Gas analysis





- Heating values similar to natural gas and superior to biogas
- Chemicals recovery from the permanent gas: (ethylene and propylene)
- Not all the species are quantitatively measured  $(C_{5+}) \rightarrow$  additional recovery of chemicals
- Removal of trace components such as HCN from ABS and halogens HCl and HBr from PVC and from flame retardants in scrubber

#### ABS Condensate GC-MS and refining tests





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#### **SR** – Sorting residue Catalytic upgrading



#### **Mass Balance**



#### **Pyrolysis** Core process of plastic circular economy







# **Ecological balance pyrolysis**

Substitution primary energyBase 1 t model mixture post-consumer plastic waste



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## **Summary and outlook**



- Pyrolysis of mixed plastic waste materials with different thermal properties.
- Particle-free liquid and gaseous products for chemical recycling of plastic waste.
- Pretreatment and adapted pyrolysis process are mandatory.
- Selective removal of chlorine by dry in-situ sorption with alkali/earth alkali compounds.
- Catalytic pyrolysis enables advanced pyrolysis products.
- Ecological evaluation with mechanical recycling and combustion reveals the potential of plastics pyrolysis.

#### Refining of products according to FCC and steam cracker requirements.



#### **Post-consumer mixed plastic waste - MPW**

Plastics 2013	Plastic waste total		Plastic waste Post-Consumer		Plastic waste Post-Industrial kt		Model mixture
	kt	%	kt	%	Producer	Processor	%
PE-LD/LLD	1446	25,5	1310	27,6	11	125	30,0
PE-HD/MD	750	13,2	631	13,3	6	110	15,0
РР	955	16,8	797	16,8	13	145	15,0
PS	290	5,1	263	5,5	2	25	10,0
PS-E	117	2,1	91	1,9	3	23	0,0
PVC	647	11,4	520	11,0	13	114	10,0
ABS, ASA, SAN	98	1,7	74	1,6	1	23	10,0
PMMA	32	0,6	26	0,5	1	5	0,0
PA	84	1,5	59	1,2	4	21	0,0
PET	568	10,0	520	11,0	3	45	10,0
Misc.							
Thermoplastics	129	2,3	89	1,9	6	34	0,0
PUR	243	4,3	182	3,8	6	55	0,0
Misc. Plastics	320	5,6	185	3,9	2	133	0,0
Total	5679	100,0	4747	100,0	74	858	100,0







H<sub>2</sub>C<sub>2</sub>

CH<sub>2</sub>



Source: Analyse/Beschreibung der derzeitigen Situation der stofflichen und energetischen Verwertung von Kunststoffabfällen in Deutschland Consultic Marketing & Industrieberatung GmbH für ITAD, April 2015

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# **Ecological balance pyrolysis**



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