Sustainable Environment

Self Sustainable E-Waste Recycling: Generating Wealth from Waste via Zero Waste Discharge Technology

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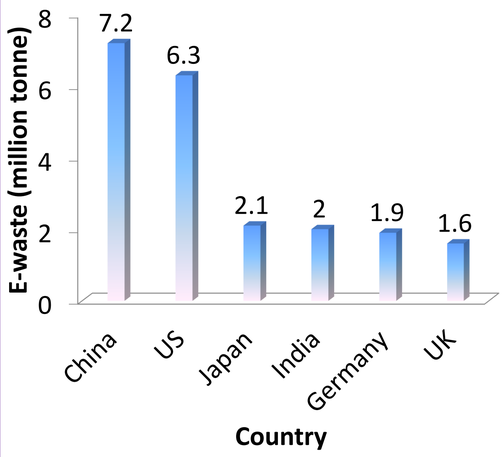
Abstract

- Electronic waste (e-waste) is fastest growing waste stream with annual growth rate of 3-5%
- E-waste generated in 2016 was 44.7 Mt and expected to grow to 52.2 Mt by 2021
- We are developing sustainable technology with zero waste discharge for efficient conversion of e-waste into fuel followed by separation of different metals for further reuse
- Pyrolysis of e-waste was carried out for recovery of metals and conversion of e-waste plastic into combustible gases, and pyrolysis pilot plant (capacity - 10 kg/h) is under construction
- Approximately 100 wt.% Cu and Ni from physically separated metal mixture was recovered using alkali leaching

Introduction



- Globally only 20% of e-waste generated in 2016 has been formally treated by the national take back programs
- Compare to ores, e-waste contains (PCB of computer) 25 – 250 times higher Gold concentration, while the concentration of Cu is 20 – 40 times higher

Polymer Composition in WEEE item

WEEE item	Polymer Composition
Printer/faxes	PS (80%), HIPS (10%), SAN (5%), ABS, PP
Computer	ABS (50%), PC/ABS (35%), HIPS (15%)
TVs	PPE/PS (63%), PC/ABS (32%), PET(5%)
Refrigeration	PS&EPS (31%), ABS (26%), PU (22%), UP (9%), PVC (6%)
Dishwashers	PP (69%), PS (8%), ABS (7%), PVC (5%)

Metal Composition in WEEE item

Type of WEEE	Metal present in abundance (%)					Metal conc. (ppm)		
	Fe	Cu	Al	Pb	Ni	Au	Ag	Pd
PC Boards	7	20	5	1.5	1	250	1000	110
TV Boards	28	10	10	1	0.3	20	280	10
Mobile Phones	5	13	1	0.3	0.1	350	1380	210

Materials and Methods

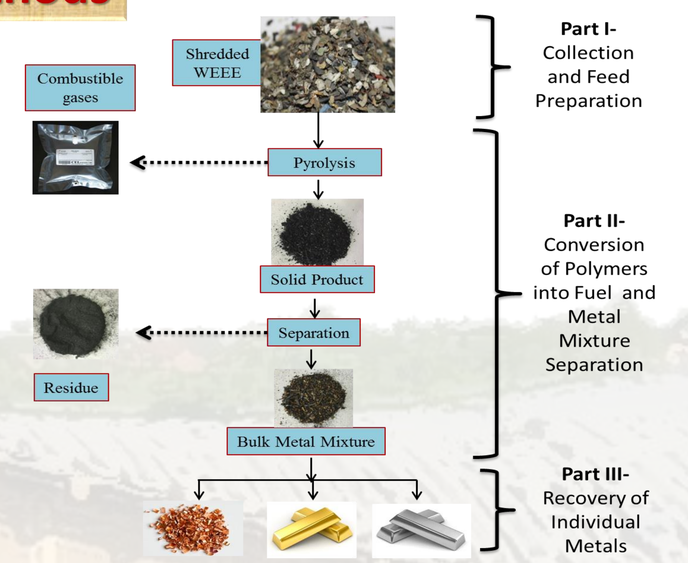
Raw Materials

Computer Printed Circuit Board

Mobile Printed Circuit Board

Reagents used for metal recovery

- NH_3, $(NH_4)_2SO_4$



Conclusions

1. The recovery of metal and production of combustible gases has been achieved using the electronic waste pyrolysis.
2. The recovery of metal fraction is more than 90% from the metal-char mixture obtained after pyrolysis, and 100% recovery of Cu and Ni is achieved from this metal-char mixture.
3. Based upon lab scale experiments 10 kg/h pilot plant for electronic waste conversion into combustible gases, diesel range oil, char and metal mixture is under construction.
4. This technology will be helpful for the minimization of e-waste with an added advantage of metal recovery and production of combustible gases.

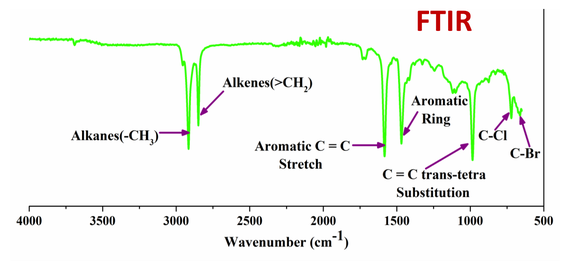
Industrial Significance

- This technology will be extremely helpful for electrical and electronics industries to fulfill extended producers responsibility (EPR) criteria.
- In addition, this technology will enable reuse of heavy and precious metals, thereby reducing overall mining cost.
- Moreover, this technology will enable industries to meet their energy demands in house via utilization of produced combustible gases and crude oil.

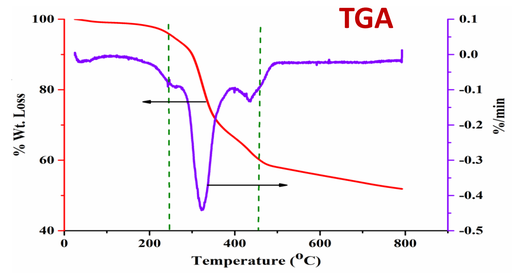
Technology Readiness Level: Technology is ready at pilot scale

Results

E-waste Characterization

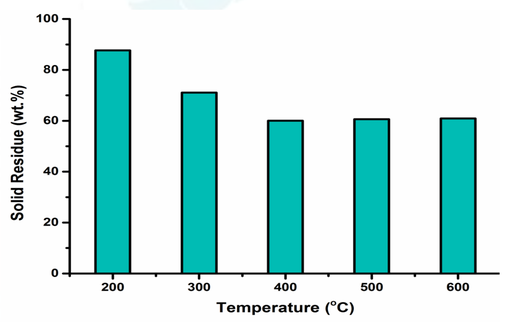


- Measured bands suggest the presence of HIPS, ABS, Polybrominated and Polychlorinated Biphenyls

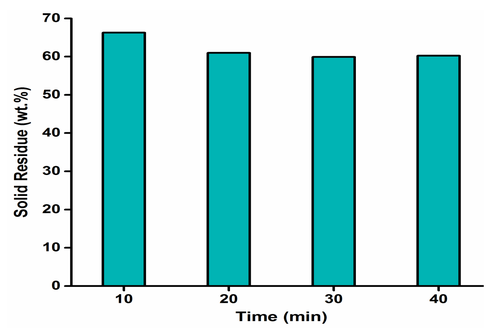


- The 35 % weight lost is observed between 250 °C – 450 °C

Pyrolysis Experiment

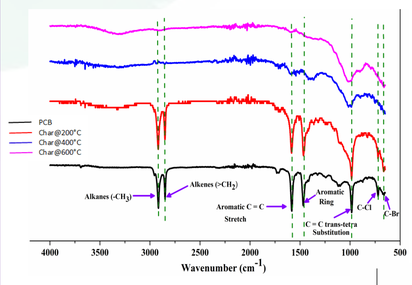


- 400 °C was found optimum operating temperature for conversion of polymers and metal separation



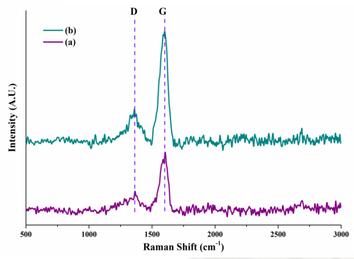
- There was no major effect of time after 20 minutes and maximum polymeric materials were converted to fuels in 20 minutes

Char Characterization



As the temperature increases to 400°C most of the band of organic functional group are disappeared which shows that polymeric material present in PCB decomposed at 400°C and above this temperature

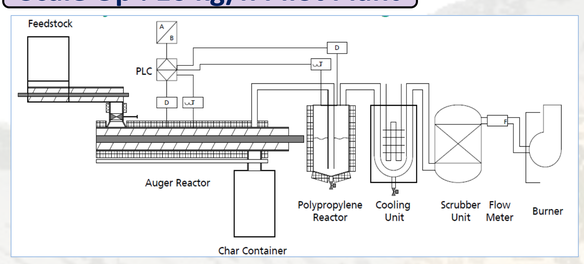
The peak at 1363 cm^{-1} corresponds to the D (defect) band and this represents the disorder in graphite structure. The peak at 1602 cm^{-1} corresponds to the G band and this band represents highly ordered graphite structure.



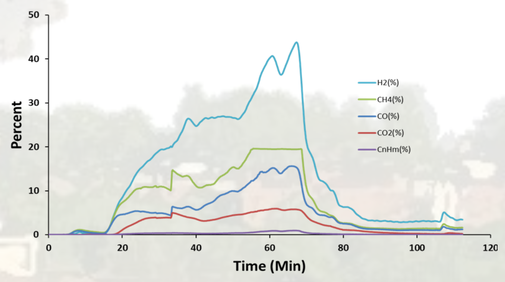
Separation of Metal Fraction

Metal	Metal in PCB	Separated Metal Mixture	% Metal Recovery
Cu	25%	63%	84
Pb	8%	10%	42
Fe	5%	12%	85
Al	1.40%	4%	97
Ni	0.64%	1.6%	87
Ag	432 ppm	1341 ppm	100
Au	1.7 ppm	5.5 ppm	100

Scale Up : 10 kg/h Pilot Plant



(a)



(b)

10 kg/h Pyrolysis Pilot Plant (a) Process flow diagram and (b) Composition of gaseous product

References

1. Chauhan G., Jadhao P. R., Pant K.K., Nigam K. D. P., Journal of Environmental Chemical Engineering, 6 (2018), 1288–1304
2. Jadhao P., Chauhan G., Pant K. K., Nigam K.D.P., Waste Management, 57 [2016], 102-112.
3. Tuncuk, A., Stazi, V., Akcil, A., Yazici, E.Y., Deveci, H. Minerals Engineering 25 [2012], 28–37.
4. Baldé, C.P., Forti V., Gray, V., Kuehr, R., Stegmann,P. : The Global E-waste Monitor – 2017, United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn/Geneva/Vienna.

Patents and Publications

1. A Process of producing fuel and recovering metals from waste electrical and electronic equipment (Application No.: 201911029549)
2. Integrated process for converting e-waste plastic into fuel and metal recovery using low-temperature roasting (Application No.: 201911035031)
3. Chauhan G., Jadhao P. R., Pant K.K., Nigam K. D. P., Journal of Environmental Chemical Engineering, 6 (2018), 1288–1304

Acknowledgement

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