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Jayanta Bhattacharya
Hony. Chief Editor

Discussion-Opinion-Editorial™

Cost, Price, Market and Value Chain Discovery of Different Waste Derived Rich Carbon Materials for Various Industrial and Commercial Applications

The author works in the area and is currently involved in multiple technology transfers with the Indian industries, and is in discussions related to the use of quasi graphitic carbon, sourced from the waste.

The ordinary coal and coking coal industry will find it increasingly difficult to supply as a sustainable source. The graphitic resources in the country are on the decline. So for the years to come, a sustainable source of rich carbon will be increasingly derived from the waste that is presently infinite and renewable. For the country and the industries, such a source would help bring down dependence on foreign raw materials and requirements of foreign exchange.

Background

The conventional and non-renewable sources of rich carbon useful for various industries and other commercial applications are on the decline. The petroleum industry that supplies carbon material for various industrial uses are under stress for resource depletion and climate control scrutiny. The ordinary coal and coking coal industry will find it increasingly difficult to supply as a sustainable source. The graphitic resources in the country are on the decline. So for the years to come, a sustainable source of rich carbon will be increasingly derived from the waste. The waste in the discussion are agricultural waste, polymer and plastic wastes, asphalt and road tar waste-with their intrinsic varieties, to name a few. However, there are various challenges to the sourcing and securing the waste, processes and realizing value as well as market discovery, establishment of capacity and networks and sustainable business models. The project will look into the above aspects.

The Social Outcome

Using agricultural waste like wood, crop residues and plastics paves way for valorization that will help the poor at the bottom of the pyramid. Consider the case, when the farmers will be able to sell the various agricultural waste and residues that they now mostly burn or use for negligible value. Similarly, when the plastics can be degraded to rich carbon and can reuse as fuel or a suitable replacement of coking coal. Community benefits for efficient technology and market of agricultural and other wastes can generate diverse high value high performance products while furthering higher agricultural income.

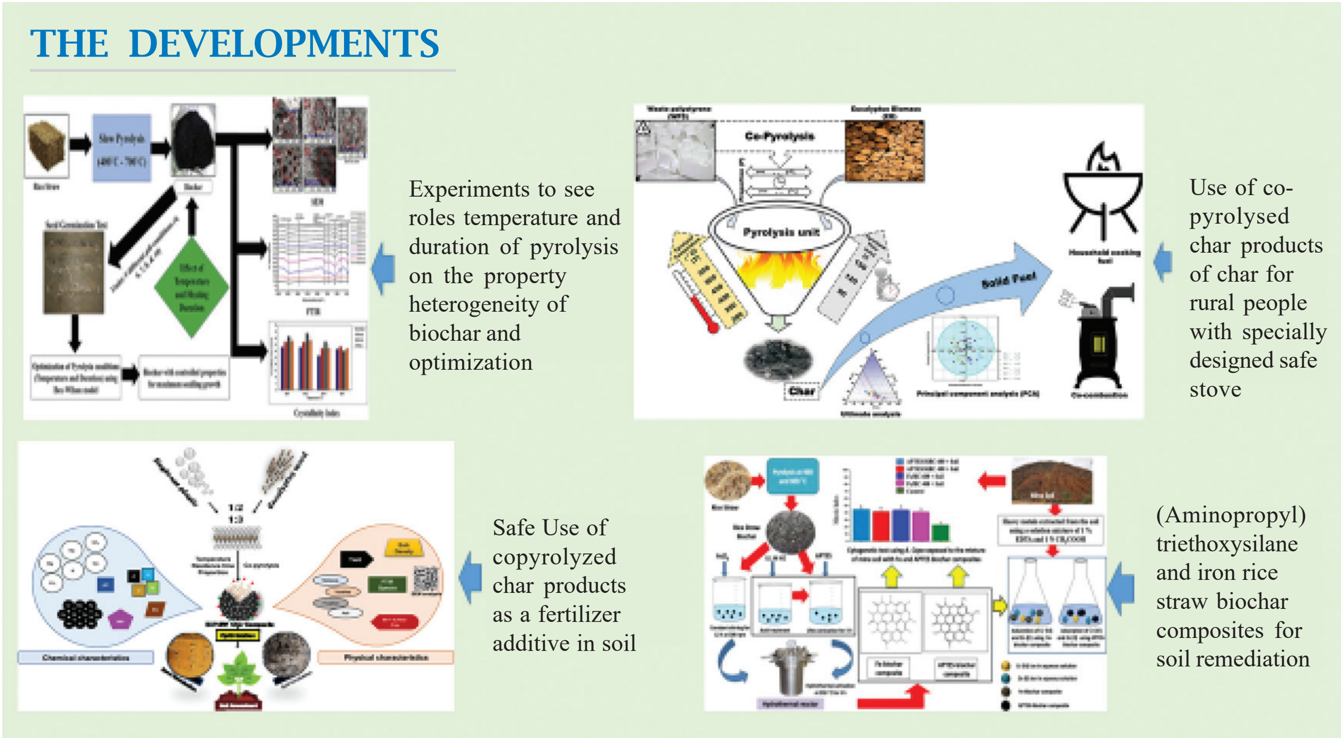


Figure 1: Some of the technologies in use

The Current Waste to Wealth Carbon Technologies

Globally the directions of research and industrial applications point to the following technologies:

1. To reduce the clinkering process time for the cement and to increase early and late strength of the concrete mix.
2. To enhance the anti-corrosive property of industrial paints.
3. For use as an additive in plastics to enhance strength and flexibility.
4. Uses in battery materials.
5. Composites for use against fruits and vegetables rotting.
6. Composites to produce a safe disinfectant to prevent Urinary Tract Disinfection.
7. Composites for photocatalytic degradation of Tetracycline in water.
8. Graphitic carbon for use in various coating surfaces including steel.

The current waste to wealth technologies in focus are:

1. Segregation and sizing
2. Incineration
3. Pyrolysis
4. Co-pyrolysis
5. Biodegradation
6. Bioleaching
7. Post processing
8. The combination of the above

The Figure 1 gives a snapshot of the current technologies in developmental phase in focus.

Specialty Graphitic Carbon from Waste for the Steel Industry

The world is focused on developing highly valuable graphitic carbon material that can be used for anti-corrosive coatings on steel pipes. Some carbonaceous waste materials can be processed to have graphitic structure that are popularly known as “Graphene similars”. “Graphene similars” offer a superb corrosion protection to steel owing to its unique impermeability to gases/liquids. Moreover, the steel will own a superior conductivity of graphene. The functionalized carbon from waste, produced by various physical, chemical and thermal processes shows persistent anticorrosive and antimicrobial properties in lab scale. Such application can increase the processes face challenges of knowledge, control, optimization and yield. There can be multiple usage of such materials in the finished products of steel. Furhter, addition of these materials can help in conductivity, more strength per weight, adding ductility to the coating surface.

Among several properties mentioned previously, properties such as high degree of electrical conductivity together with promising anti-corrosion properties of graphene can provide technological solutions to the customers of steel industry and fulfill their demand of constantly developing novel and more sophisticated products. Coating plays a crucial role in improving surface quality and providing protection for a substrate. Graphitic carbon of "graphene similars" based advanced functional coatings can prove to be a "game changer" material for steel industry and its customers. The possibility to produce large quantities of high quality "graphene similars" and innovating different methods to deposit functional coatings based on these materials on steel substrates is driving the research and development of innovative technology in steel industry for various application. For example, such "graphene similars"-coated steels could boost the energy efficiency of solar panels, or make buildings longer lasting by reducing damage caused by water or corrosive environment.

Some carbonaceous waste materials can be processed to have graphitic structure that are popularly known as "Graphene similars". "Graphene similars" offer a superb corrosion protection to steel owing to its unique impermeability to gases/liquids. Moreover, the steel will own a superior conductivity of graphene. The functionalized carbon from waste, produced by various physical, chemical and thermal processes shows persistent anticorrosive and antimicrobial properties in scale.

Figures 2 and 3 provide the use of graphitic carbon in various processes.

Objectives of Current Research

1. Identification of specialty and mass-scale waste carbon sources.
2. Production of "graphene similars" in lab scale setup to experience the challenges of such technologies.
3. Use of "graphene similars" in various steel surface coatings and finding out the performance measures.
4. Methods of understanding valorization of waste for various industrial and other commercial uses.
5. Cost, price, market and value chain discovery of the identified products and technology by critical measures like quantity and size.

Methodology

1. Review of the current technologies of harnessing rich carbon from various waste resources.
2. Technology testing by prototype building to obtain carbon resources from the waste, feed stock selection and characterization of the carbon rich products for steel coatings and other technology uses.
3. Response of the user industry in using such products in their processes and determination of the expected market response.
4. Examination into how value addition can be done to the products and the market by creating new value chains and services.
5. The assessment of the total cost of production of waste to wealth new carbon rich products and the market 's readiness to pay for the value.
6. How the carbon recovery from the waste can be made more sustainable using emerging technologies.
7. Creating a data base and compilation of reports for circulation.

Waste to Wealth and Industrial Ecology

Recent and Ongoing Research	Research to Product
1. Use of char products to reduce the clinkering process time for the cement and to increase early and late strength of the concrete mix. 2. Use of char products to enhance the anti-corrosive property of industrial paints. 3. Use of char products for use as an additive in plastics to enhance strength and flexibility. 4. Use of char as battery materials 5. Use of char composites for use against fruits and vegetables rotting. 6. Use of char composites to produce a safe disinfectant to prevent Urinary Tract Disinfection. 7. Use of char composites for photocatalytic degradation of Tetracycline in water	1 A char based product is now a marketed product called "Happy Milk" (a patented product), a cattle metabolic regulator of a Startup incubated with IIT Kharagpur. 2 A char composite is now under active trials in the market for use as rot preventer of fruits and vegetables. 3 Use of graphitic carbon in refractory bricks and liners 4 Use of graphitic carbon in jute bags.

Figure 2

THE PROSPECTS FOR STEEL INDUSTRY USING GRAPHITIC CARBON

The corrosion of steel results in the loss of original cross-section, as well as up to six times the volume expansion causing debonding of rebar from concrete, ultimately resulting a failure of the composite material system and in turn affecting the integrity of the structure

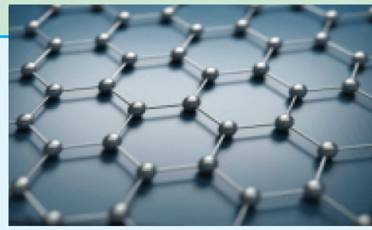
Application of an anti-corrosive coating to structural steel and rebar embedded in concrete, can be an effective solution.

SOME COMMON DRAWBACKS

- Chemical reactions in fresh concrete with galvanized bar
- Weak bond between steel and surrounding concrete with epoxy-coated bar, and brittleness of enamel coating

- These can result in abrasion of coating layer during transportation and construction. handling, defects in the coating during fabrication, and lead to pitting corrosion.
- Polymer coatings are susceptible to high-temperature degradation and suffer from their inherent porosity.

USE OF GRAPHENE/2D GRAPHITIC CARBON

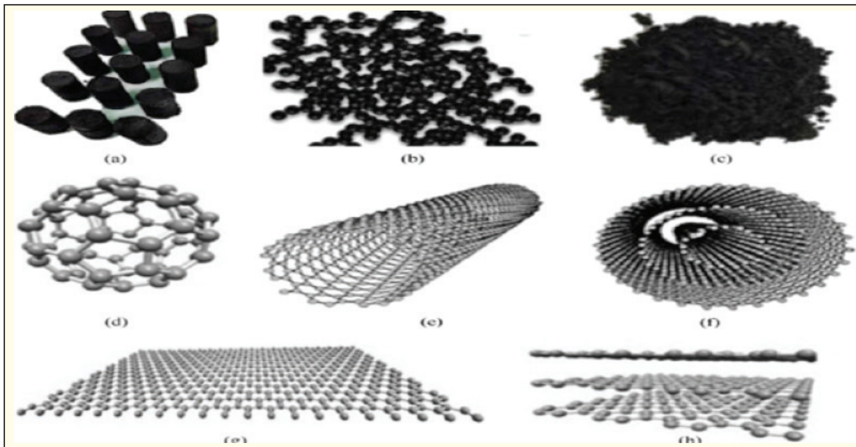


- In comparison with traditional approaches, 2D graphitic carbon has become a potentially important candidate for surface coatings against corrosion owing to its chemically inert nature and impermeability to gases and liquids, and is an emerging field of research
- As the strongest known material, graphene possesses an ultrahigh fracture strength (~100 GPa), and ultrahigh fatigue life (>109 cycles) which can benefit a structure's integrity under severe and complex loading conditions.
- Its superlubricity and ultralow friction further enables the 2D graphitic carbon-based coating to exhibit desirable properties including, high wear and scratch resistance.

CHALLENGES OF GRAPHENE

Despite substantial progress achieved in the fundamental research of graphene-based anti-corrosive coatings, the path from laboratory to industry poses daunting challenges. Some of the key significant challenges at stake for industrialization of graphene-based anti-corrosive coating include:

- The quality control of graphene materials. Scalable deposition of graphene-based coatings on substrates
- Long-lasting corrosion protection strategies
- Optimization of manufacturability to account for cost and reliability.
- The corresponding environmental impacts



Commonly applied carbon-based materials, including (a) char (compression-moulded, (b) carbon black (CB) (micro-mesopore (c) activated carbon (AC), (d) fullerene, (e) single-walled CNT (1D),(f) multi-walled CNT (g) graphene (2D), and (h) graphite (3D) [60].

Figure 3