News

John A. Glaser

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Ravi Jain: Retirement of our co-editor-in-chief

We celebrate the news of the retirement of our esteemed co-editor-in-chief, Ravi Jain. Dr. Jain joined the editorial effort of *Clean Technologies and Environmental Policy* in 2001. In his role as editor he has strengthened and reaffirmed the directions and aims of the journal. The growing science and engineering of clean technologies continues to garner significant attention in the areas of sustainability and green processes. Dr. Jain helped design the journal to provide a forum for the development, demonstration, and commercialization of cleaner products and processes complemented with the development and understanding of effective environmental policy strategies. To assist the development of authors and contribute to the understanding

of clean technology and environmental policy, Dr. Jain helped the development of yearly Best Paper and Outstanding Paper category awards which are nominated and selected by a review board.

Dr. Jain has agreed to continue in an emeritus role with the journal while he continues in a similar role at the University of the Pacific, School of Engineering and Computer Science, where he previously held positions of dean and professor. Dr. Jain came to the University of the Pacific from the University of Cincinnati where he was Associate Dean for Research and International Engineering Program, Director Environmental Engineering Management Graduate Program, Executive Director Interdisciplinary Research Centers, and Professor Civil and Environmental Engineering. Prior to the University of Cincinnati, Dr. Jain was founding director of the Army Environmental Policy Institute affiliated with the University of Illinois Urbana-Champaign. He has authored 15 books, over 180 journal articles, book chapters, and technical reports. We thank Ravi for his countless services to *Clean Technologies and Environmental Policy*.

News: Membrane engineering focused process intensification

Process intensification has been broadly heralded for its anticipated contribution to the development of new processes having smaller footprints and greater efficiencies for material and energy use. Membrane operations in chemical plants offer opportunities of integrated systems, low energy requirements, operational stability and environmental compatibility, and broad operational flexibility. Molecular separation in various configurations and functionalities can be found with membrane emulsifiers, membrane distillation,

J. A. Glaser (✉)
US Environmental Protection Agency, National Risk
Management Research Laboratory, 26 W King Dr, Cincinnati,
OH 45268, USA
e-mail: Glaser.John@epa.gov

membrane crystallizers, membrane contactors, membrane strippers and scrubbers, and membrane reactors. For water desalination, the dominant technologies are reverse osmosis and filtration (nano, ultra, and micro). This overview of membrane applications provides insight into how new processes can be designed with goals of lower energy consumption, plant volume reduction, and maximum exploitation of raw materials. The authors offer a perspective for the application of membrane technology to hydrogen production and distillation where membrane reactor and membrane distillation applications are considered as case studies. Green process engineering can be achieved through the redesign of traditional operations as membrane systems guided by the objectives of process intensification.

Green Chem 2012, 14, 1561–1572.

Reactionware for chemical synthesis from a 3D printer

A remarkable use of 3-dimensional printing has produced reactionware to initiate chemical reactions in which the reagents are printed directly to a reactionware matrix.

3D printing uses a computer-generated design to form a geometric figure. Each layer of the 3D image assists the

development of figures ranging from chemical lab ware to growing human body parts. For lab ware, successive layers of plastic or metal are applied and solidified through heat curing or sintering with a laser.

Products ranging in size and complexity can easily be formed at a large scale. The product templates can easily be adapted and customized by simple alteration of the computer-based design. The process control enables manufacturers to create cost-effective products tailored to customer specifications. The process offers the possibility of using less material in a myriad of applications. Acetoxysilicone bathroom sealant was used to construct the reactionware with a 3D printer dispensing controlled amounts of polymer to build the designed 3D figure.

A demonstration of this new technology can be seen in the reaction of 3 equivalents of 5-(bromoethyl)-phenanthridinium bromide with 1 equivalent of 4-methoxyaniline DMSO solution. Two reactors were fabricated using a 3D printer. Reactors A & B differ by reaction chamber volumes. Reaction between reactants was caused to occur through the application of a vacuum, which moved the solutions of reactants from their solution holding chambers to the mixing/reaction chamber. As shown in the reaction scheme below, these volume changes led to different results!

Reactor architectures were developed for the synthesis of two new nanoclusters. A remarkable example of this new technology can be found in an example in which catalysts were printed directly into the reactionware. Ethyl benzene was hydrogenated in reactionware impregnated with Pd/C using Et₃SiH according to a known procedure. Clearly, these findings offer a vast landscape of potential applications in chemistry, biology and beyond. *Nature Chemistry* 2012, 4, 349–354; *Chem Ind* 2013, 77, 16–18; *Nature* 2012, 487, 22–23.

A fluorocarbon climate bomb

In this 20 page report entitled: *Two Billion Tonne Climate Bomb: How to Defuse the HFC-23 Problem* released by the Environmental Investigation Agency (EIA) which details the situation arising from the production of HCFC-22 a refrigerant, a foam blowing agent, and starting material for the synthesis of commercial polymers. HCFC-23 is an ozone-depleting chemical. According to the Montreal Protocol, HCFC-22 is scheduled for phase-out by 2020 in the developed countries and 2030 for the developing nations.

The production of chlorodifluoromethane (HCFC-22 or CHClF₂) generates the by-products, trifluoromethane (HFC-23), and dichlorofluoromethane (HCFC-21 or CHCl₂F), from the fluorination of chloroform by antimony pentachloride in the presence of hydrofluoric acid.

Trifluoromethane has been identified as one of the most damaging greenhouse gases discharged to the atmosphere. This chemical has been assessed to exhibit GHG properties 14,800 times more damaging than carbon dioxide.

Trifluoromethane has limited uses as a chemical intermediate leading to the need for destruction of copious amounts of this chemical generated daily from a vast array of fluorocarbon production sources. The Clean Development Mechanism (CDM) of the United Nations Framework Convention on Climate Change has developed a series of incinerators at 19 HCFC-22 manufacturing facilities spanning Argentina, China, India, and South Korea. Billions of dollars in windfall profits were received by each CDM plant from the sale of HCFC-22 carbon credits. Yet there are some 127 million tonnes of HFC-23 discharged annually to

the atmosphere from non-compliant manufacturing facilities. The windfall credit money was not applied to the non-compliant CDM plants. EIA has conducted investigations to determine industry practice for non-compliant plants. In India and China, EIA has found that existing production lines have been venting millions of tonnes of HFC-23 despite the availability of accepted destruction techniques and treatment capacity. Best available destruction technologies and maintenance practices lead to a 99.99 % destruction of HCFC-22 emissions.

Lest we think the problem is only elsewhere on the globe, two US HCFC-22 production plants are reported to have released some 460,000 tonnes of emissions for 2011. EIA suggests that the US can assist the global situation by reducing domestic US emissions thereby leading to problem solution.

The Environmental Investigation Agency is “an independent campaigning organization committed to bringing about change that protects the natural world from environmental crime and abuse”.

http://www.eia-international.org/wp-content/uploads/EIA_HFC-23_report_0613_Final.pdf.

Nanomatter toxicology

Engineered nanomaterials (ENMs) have been developed to a production scale that can support consumer product development. The novel physicochemical properties of ENMs are largely unknown and could lead to hazardous biological conditions. An issue of *Accounts of Chemical Research* is devoted to the considerations of environmental health and safety for nanotechnology. The necessary safety assays should be robust for in vitro or in vivo assessments designed to investigate the myriad biophysicochemical interactions at the nano/bio interface. One group of researchers developed a predictive toxicological approach using mechanism-based high-throughput screening in vitro to enable predictions of the physiochemical properties of ENMs to permit identification of pathologic or disease effects in vivo. ENM libraries will be developed to include combinatorial variations of properties such as shape, size, crystal structure, band gap, dissolution, surface chemistry, surface charge, and surface functionalization.

Another research group seeks to understand how nanomaterial properties affect bioavailability, transport, fate, cellular uptake, and initiation of injurious biological responses. The impact of ENM physicochemical properties is investigated to elucidate how they affect cellular bioprocessing. The research is expected to assist the development of safer nanotherapeutics through a better understanding of the nano-bio interface.

Acc Chem Res 2013, 46, 3, 605–872.

Energy efficiency and political ideologies

Two separate survey studies of United States residents have explored the importance of political ideology to attitudes and choices affecting energy-efficiency promotion efforts. The first study was conducted with a population of 657 US participants with a composition of 49/51 % male/female ranging in age from 19 to 81 years. A short description of energy efficiency was conveyed to all participants. A series of questions queried the psychological value that each participant accorded to the goal of reducing carbon emissions, reducing foreign oil dependence, and reducing energy cost to the consumer. Politically conservative individuals were found to be less in favor of investment in energy-efficient technology than more liberal participants. The more conservative individuals placed less value on the environment, energy independence, and energy costs.

The second study was designed to investigate how labels reflecting environmental concerns affect individual's choices regarding the purchase of an energy-efficient product when people are aware of the cost savings that energy efficiency can provide. The population of 210 participants was taken from a US university with a composition of 39/61 % male/female ranging in age 18–66 years. Each participant was given US \$2.00 to buy an electric light bulb from a collection of available products with the same price options. The choice was constrained to incandescent and compact fluorescent light options. The incandescent light was half the price of the fluorescent light. The bulbs produced the same light intensity. The compact fluorescent light came with “Protect the Environment” or blank stickers. The study found that linking energy-efficient products with environmental concerns may negatively affect the selection of these products by purchasers who are more politically conservative. The researchers interpreted results as demonstrating the ideological differences toward energy efficiency in the US. It appears that a more politically conservative ideology leads to less support for energy efficiency. Despite the obvious beneficial effects of energy efficiency to environmental protection not everyone values these benefits. While these results are very interesting, the study needs to be replicated to understand the strength of its conclusions.

PNAS 2013, 110, 9191–9192, PNAS 2013, 110, 9314–9319.

Environmental benefits from carbon markets

Economic growth can be significantly stimulated by reforms to global carbon markets as supported by a 40 page report released by The Center for American Progress. The report: *Carbon Market Crossroads: New Ideas for*

Harnessing Global Markets to Confront Climate Change supports the contention that carbon markets can generate benefits in the environment and economy by undertaking some significant and beneficial changes. The stimulation of economic growth, realized through enhancement of multiple billion dollar investments in private-sector development, and reduction of global poverty could lead to the “outsized environmental and economic benefits” generated by global carbon markets where certain advocated reforms are implemented.

The report states that the planet could warm by 4 °C in the next one hundred years, should the espoused reforms be ignored or receive little attention. These goals can be accomplished through the enactment of proposed reforms in the near term to garner maximum effect since delay will lead to circumstances where global atmospheric recovery becomes impossible.

Recommendations offered in the report call for international summits, investment of political resolve to assist the global carbon markets, dropping fossil fuel subsidies, and changes to the climate change goals participating nations. The report stresses the need for communication with consumers of technological innovations to insure that critical evaluation of a technology is conducted in terms of insuring minimal effect to climate change.

The Center for American Progress has identified itself as “an independent nonpartisan educational institute focusing on progressive ideas and action”.

<http://www.americanprogress.org/wp-content/uploads/2013/04/CarbonMarketCrossroads-3.pdf>.

Hardrock mining pollution assessment

Existing and proposed hardrock mines in the United States could pollute up to 48 billion gallons of water each year in perpetuity. According to the report *Polluting the Future: How Mining Companies are Polluting our Nation's Waters in Perpetuity* aqueous pollution from hardrock mining enterprises is quite significant and is expected to increase. The report released by Earthworks, “a nonprofit environmental organization concerned with the impacts of irresponsible mineral and energy development” offers some insight into the massive environmental problem stemming from this pollution and its potential increase. Pollution from hardrock mines involved in the extraction of gold, copper, and uranium could provide a legacy lasting hundreds or thousands of years if not properly managed.

The primary source of long-term water pollution at hardrock mine sites is acid mine drainage, where sulfur oxide acids leach metal from the adjacent rock. Acid mine drainage is a pollution source that will contaminate drinking water aquifers. Long-term public health risks and

harm of the fish and wildlife in the ecosystem can arise for exposure to the mobilized metal species. The report calls for US regulatory authorities to use their authority under the Clean Water Act and the Comprehensive Environmental Response, Compensation, and Liability Act to protect waterways from mining waste disposal. The report asserts that mining companies can be required to accept financial responsibility for water treatment of pollution released by their mines but with the impending timeframe for the pollution these considerations may not be long-term solutions due to the expected corporate lifetime.

An estimated 17–27 billion gallons of polluted water can be generated by 40 existing mines annually into perpetuity. Water treatment at those mines could cost \$57–\$67 billion per year, according to the report. Many of the mines are located on public lands, so the costs of treatment are often left to taxpayers if a mining company is unable or unwilling to clean up the site, Earthworks said.

Estimates of the long-term public liability are for the cleanup of abandoned mine sites show mountainous resource needs. Taxpayers are expected to defray the cost of water treatment across centuries, which extend far beyond the expected life of any current mining corporation(s).

Another 13 existing mines are likely to generate water pollution in perpetuity, potentially generating an additional 3.4–4 billion gallons of polluted water each year. Four proposed mines analyzed in the report are expected to result in 16.7–16.9 billion gallons of water pollution annually.

http://www.earthworksaction.org/library/detail/polluting_the_future.

9th Warmest year on record: 2012

The World Meteorological Organization (WMO) has data to show 2012 was the ninth-warmest year on record. It is

also the 27th consecutive year in which the average land temperature exceeded the 1961–1990 average.

The WMO's annual report: *Statement on the Status of the Global Climate* concluded that climate change is a source of uncertainty for the energy and agriculture industries. Climate change was found to be affecting the naturally occurring climate variability. The WMO asserts that the consequences of extra energy capture contained in the greenhouse gases by the oceans, the attendant acidification and other impacts demand intense study are largely unknown. Most of the land surface areas of the world (North America, western Russia, southern South America, parts of northern Africa, and southern Europe) reported above-average temperatures for 2012. Greenland and the Arctic exhibited record ice melts as another disturbing sign of climate change. Greenland's ice surface sheet had melted by 97 % in July corresponding to the largest melt extent since satellite monitoring was undertaken. The Arctic showed the lowest reported annual ice levels.

https://www.wmo.int/pages/mediacentre/press_releases/documents/WMO_1108_EN_web_000.pdf.

Green metrics assessment of chemical processes using phosgene

Phosgene was discovered two centuries ago. The very poisonous gas has been used to produce an extensive array of industrial chemicals and intermediates. A litany of well-known derivatives of phosgene includes urea, dimethyl carbonate, methyl carbamate, and carbaryl. Phosgene was employed as a chemical weapon in World War I as a pulmonary agent and is claimed to be responsible for 80 % of the chemical gas fatalities.

Phosgene is a gas at room temperature. Due to its toxicity and high hazard designation, phosgene is generated on-site for the various desired chemical transformations and syntheses. Diphosgene and triphosgene which are a liquid and solid, respectively, have been synthesized to permit the more controlled use of phosgene since each decomposes to phosgene.

Phosgene

Diphosgene

Triphosgene

Reaction Mass Efficiency $RME = \epsilon(AE)/(1/SF)(MRP) = 1/(1 + E)$

Unreacted starting materials E-kernal = $[1/\epsilon(AE)] - 1$

Excess reagent consumption E-excess = $[(SF) - 1] - 1/\epsilon(AE)$

Purification operations E-aux = $[(SF)/\epsilon(AE)][1/MRP] - 1]$

E-total = E-kernal + E-excess + E-aux

Since important industrial commodity chemicals are derived from phosgene, it is important to contrast phosgene/phosgene-free chemistries currently available in terms of green metrics. Multiple synthetic schema for dimethyl carbonate, diphenyl carbonate, diphenylurea, methyl carbamate, methyl chloroformate, methyl *N*-phenylcarbamate, methyl phenyl carbonate, phenyl isocyanate, phenyl chloroformate, and urea were analyzed and compared by green metrics to determine the most material-efficient routes. Radial pentagon analysis was used to assess the green metrics to find how reaction performance varies for individual reactions using the various sources of phosgene (phosgene, diphosgene, triphosgene, and dimethyl carbonate). The radial pentagons displayed each reaction features in terms of atom efficiency, reaction mass efficiency, stoichiometric factor, material recovery parameter, and reaction yield. Radial pentagon and E-total analysis have been found to effectively identify material-efficient synthetic routes, any bottlenecks, and directions for future optimization.

Pure Appl Chem 2012, 84, 827–860.

Mountaintop mining unexpected effects

The demand for low sulfur coal as a fuel for steam-electricity production and other energy uses has driven the extraction process to involve mountaintop-removal mining in the eastern US. With the advent of equipment able to remove the overburden, the coal seams could be mined effectively. In the mountains, a 65-county area extending

from West Virginia to Tennessee has been targeted for coal production using mountaintop mining. The overburden (mountaintop) is removed by high capacity, aggressive earth moving technology such as draglines where a single scoop of this equipment can remove 100 yd³ (76.5 m³). The ecological impacts of this practice can be viewed using Google Maps. The researchers use Google Maps to display an area proximate to Mud River, West Virginia. Visual intercomparison of before/after maps clearly documents the extent of devastation to the general environment of this location using these mining techniques. While negative visual effects are compelling, it cannot show the inherent effects to the local ecology that include water-quality impacts on streams of the area and the aquatic life therein. The practice of mountaintop mining had been controversial and targeted for controls by current legislation; however, environmental impact reporting has been centered on aquatic resource effects. The removal of mountaintops and disposal in the adjacent valleys and ravines leads to the filling of these topological voids. Streams buried in this process contain the aquatic resources of concern. The numerous impacts to the terrestrial environment must be evaluated. Mining impacts such as loss of topological complexity, loss and fragmentation of forestlands, soil loss and forest succession, loss of carbon sequestration capacity, biodiversity, and human health can be widely ranging, severe, and multifaceted. This paper seeks to expose for future research the unaddressed impacts to the terrestrial environment and to design a more comprehensive environmental assessment of this mining technique.

Bioscience 2013, 63, 335–348.

Electric vehicle environmental impact advantages

Electric vehicles are perceived to limit pollution due to zero tailpipe emissions with lower maintenance requirements, and other desirable features. Assessment of the total environmental impact across the lifespan of an electric vehicle was found to be not much different than a corresponding fossil-fuel powered vehicle. Researchers investigated the total life-cycle effects beginning with production and ending with disposal the study vehicles. Electric vehicles, due to the use of greater amounts of copper, nickel, and other metals with toxic production byproducts, were found to have a greater potential for human and freshwater toxicity than diesel and gas powered vehicles. Greater metal depletion potential was identified with electrical vehicles since they are about three times more likely than conventional vehicles to use scarce metals in their production. Electric vehicles of a 100,000 km, or 62,000 mi lifetime, are expected to reduce global warming potential over gasoline vehicles by 9–14 % leading to

indistinguishable environmental benefits in contrast to diesel vehicles.

The study found that transitioning to electric vehicles may be a case of problem-shifting in which emissions are moved away from the road rather than reducing them globally.

J Indust Ecol 2013, 17, 55–64.

Nanotechnology contribution to electric vehicle batteries

Nanotechnology, implicit to lithium-ion batteries employed as power sources and storage in electric and hybrid electric vehicles, can reduce the environmental impact of the batteries according to the report *Application of Life-Cycle Assessment to Nanoscale Technology: Lithium-ion Batteries for Electric Vehicles* EPA 744-R-12-001. Single-walled carbon nanotube anode technology can increase the energy efficiency of lithium-ion batteries. Anode production is energy-intensive and could overwhelm any energy efficiency benefits attributable to batteries use. Energy reduction of the anode manufacturing process is expected to improve the environmental impact. The report is a product of a collaboration of EPA, the Energy Department, and Li-ion manufacturers, battery recycling companies, research and trade organizations, and university researchers. A life cycle assessment for lithium-ion batteries begins with manufacturing process evaluation to battery recycle after use. Lithium ion batteries using nickel and cobalt as part of their construction and solvent-based electrode processing were identified as having the highest environmental impact. Resource depletion, global warming, ecological toxicity, and negative human health impacts are characteristics of the manufacture of these types of batteries. Cobalt and nickel metal compounds elicit harmful respiratory, pulmonary, and neurological effects in humans. Material substitution, changes to electrode processing to avoid solvent use, and recycling batteries are expected to reduce these impacts.

<http://www.epa.gov/dfe/pubs/projects/lbnp/final-li-ion-battery-lca-report.pdf>.

Honey bee colony decline

The importance of honey bees to commercial agriculture cannot be overstated. The bees are required for the pollination

of flowering plants basic to agricultural production. The recent colony collapse disorder observed in US bee populations is under study with analytical reports expected.

The Environmental Protection Agency and the US Department of Agriculture have released a report, which calls for additional research and improved data collection to address whether pesticide exposure is contributing to declining pollinator populations. The report, *Report on the National Stakeholders Conference on Honey Bee Health*, identifies factors believed to play a role in the decline of honey bees and other insect pollinators. The factors identified are the varroa mite, viruses, poor nutrition, and a lack of genetic diversity within US honey bee colonies. Pesticide exposure was recognized as a major factor contributing to pollinator population decline and high-dose exposure to insecticides can “severely harm” some honey bee colonies. Acute and sublethal effects of pesticides on honey bees were enunciated as “a primary concern.”

Actual exposure levels for pollinators in the field and the effects of long-term exposure to multiple pesticides on bee health and the productivity of bee colonies must be determined. Semi-field and field-risk research concerning pesticide exposure, acute and sublethal pesticide effects on honey bees, and improved communication to reduce pesticide exposure are necessary to address the concerns of growers and bee keepers.

<http://www.usda.gov/documents/ReportHoneyBeeHealth.pdf>.

New journals

A new transdisciplinary open access journal, Earth’s Future seeks to engage researchers and policy makers in the effort to develop a better understanding and management of our relationship with the Earth. Part of the new journal’s mission is to assist the public and policy makers in a more complete understanding of the science that is fundamental to the planet’s future. Original research, reviews, essays, and commentaries bridging the confines of the life, physical, and social sciences are targeted for publications where Earth and environmental challenges are related. Areas of pollution increase, industrial and agricultural development, urbanization, climate change, and energy are selected topical foci for the journal.

[http://onlinelibrary.wiley.com/journal/10.1002/\(ISSN\)2328-4277](http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)2328-4277).