Publications in organic chemistry from Indian universities and laboratories in 2011–2013: analysis and some suggestions

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An attempt to analyse the pattern of organic chemistry papers in national and international journals was made in this article. We have reviewed the papers published in various subject areas and presented our findings. There is a growing interest in publishing papers in heterocyclic compared to other areas. There is a need for publishing more review papers in fundamental areas in the frontier research segment particularly to benefit the university teachers. We also have analysed the trend of the researchers and their papers. It was found that there is more enthusiasm to publish papers in higher ranking international journals than the premier journals like IJC(B). The neglect of national journals would hurt the research in the country. Effective uses of new synthetic methodologies involving metal catalysed reactions are found in international publications. However, development of new methodologies, new reagents and serious structure–activity relationship in medicinal chemistry were not visible in the research papers.

Keywords: Organic chemistry, impact factor, subject-wise analysis.

IN January 2012, the *Indian Journal of Chemistry* (*Organic including Medicinal Chemistry, Section-B*) (*IJC*(*B*)), published an analysis titled 'Visibility and impact of the *Indian Journal of Chemistry* (*B*), during 2005–2009 using Scientometric technique'[1]. The review of *IJC*(*B*)[1] was made purely on the basis of software with respect to impact and citation factors. On the basis of the analysis, the editorial[2] in the journal concluded that more than 50% of the papers constitute the synthesis of heterocyclic compounds of all the papers published. It also pointed out that chemists in India tend to publish in international journals with high impact factor[2]. In this article we present an analysis of organic chemistry research papers published by Indian scientists in Indian and international journals during 2011–2013. It is to be remembered that outside India, Indian research and its publications are viewed through *IJC* and the *Journal of the Indian Chemical Society* (*JICS*), since these are viewed as national journals. Some suggestions to improve the standard of articles from India are also presented here. This analysis is based on a study of the published papers/abstracts[3] and not on 'scientometrics or computer-based' study.

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Analysis of papers published in *IJC* 2011–2013

At the outset we review the papers published during 2011–2013 in *IJC*(*B*) from the subject point of view, both with respect to institution and sub-areas of organic chemistry, since it is the most important journal in organic chemistry in India. The study reveals that a large number of published papers during 2011–2013 are from state universities including the affiliated PG colleges (70–80%) (Table 1). The contributions of national institutes/universities which include Central Universities, CSIR, IIT, IISc, IISER and NIPER during 2011–2013, range from 4% to 13% private and deemed universities 0.85% to 6% and private pharma, including custom research organizations (CROs) 3.53% to 6%. Sub-area subject-wise a large number of papers are from heterocyclic synthesis – 76% in 2013 (Table 2). The study of medicinal properties is not serious enough, confined mostly to anti-bacterial activity with no SAR – structure activity relationship.

There is only one review that appeared in January 2013 with the subject 'Asymmetric Henry reaction'. There is a need for more such reviews for the enhancement of knowledge in the frontier areas given the limitations we have, with the universities/Central Government institutes across the country having stopped subscription to international journals and books. Not many institutes have on-line subscription facility. Therefore, such reviews provide insights into the advancing frontiers of the last decade. It is essential that chemists in the universities,

Table 1. Papers published in *Indian Journal of Chemistry B (Organic including Medicinal Chemistry, IJC(B))* during 2011–2013

Year	No. of papers	State universities, including affiliated PG and pharmacy colleges (%)	CSIR laboratories (%)	Central universities/ institutes (%)	Private universities, including deemed universities (%)	Private pharma (%)*	Foreign
2011	116	81 (69.82)	14 (12.06)	9 (7.75)	6 (5.17)	5 (4.31)	1
2012	114	79 (69.29)	9 (7.89)	14 (12.28)	1 (0.87)	7 (6.14)	4
2013	113	90 (79.6)	10 (8.84)	5 (4.42)	–	4 (3.53)	4

*These include private R&D and Contract Research Organizations.

Table 2. Papers published according to sub-areas of organic chemistry in *IJC*(*B*) 2013

No. of papers	Reviews (%)	Heterocyclic synthesis (%)	Natural products (%)	MISCC. aliphatic/aromatic/ synthesize/spectra (%)	Foreign
113	1 (0.88)	86 (76.1)	8 (7.07)	18 (15.9)	–

where teaching is the main activity need to understand the frontier research areas. Therefore, detailed review articles on metal (Ru, Rh, Pd, Pt) catalysed asymmetric synthesis, including ring closing metathesis, Suzuki coupling, to cite a few, should be welcomed.

Subject-wise analysis (IJC(B) 2013 year)

Steroids: There is one paper wherein estrogen and estradiol are used as starting materials to perform a series of reactions. The need of the hour is to have similar papers focusing on fundamental building blocks.

Natural products: These by definition include chemical examination of plants, marine, bacterial and fungal metabolites. During 1980s, papers from plant natural products predominated in *IJC*, but in 2013, only eight papers were published. These include the isolation and structure determination of new products from plants, example *Curcuma caesia*, *Calotropis procera*, *Feronia limonia*, *Lagascea mollis*, *Ageratum conyzoides*, *Pouzdkzia indica*, *Cassia abus*, *Endophytic fungus* and *Dendryphion nanum*. Natural products are our wealth. India is endowed with rich biodiversity and it is our duty as chemists to research and reap the benefits. During the era of late T. R. Seshadri, K. Venkataraman, Ahima Chatterjee and Sukh Dev natural products research from India dominated the international scene as well. On synthetic side of natural products, the side chain synthesis of taxol was reported. The synthesis of lactorochromal, a metabolite of fungus and of atovaquone were also reported.

Carbohydrates: There was a paper on the conversation of glycosyl azides to glycosyl cyanamide, a Chinese paper on the synthesis of glycosides and one more paper on selenourea tethered glycosylated amino acids, a total of three papers on carbohydrates.

Synthetic reactions: There was a paper on Mukaiyama aldol condensation, two papers on Knoevenagel reaction, and papers on pyrrolidine catalysed Aldol reaction (diasteroselectivity determined by ^{1}H NMR), Michael reaction, β-amino-β-ketoesters and Claisen–Schmidt reaction. In all nine papers were published under this category. Resolution (R)- or (S)-binal and iminodields–Alder reaction are other interesting papers. A paper on new brominating agent, tetraethyl ammonium bromate and potassium bromate was also published.

Theoretical studies: One paper on molecular orbital calculation of ampillicin and another on QSAR studies on a pyrrolidine-based product were published.

Spectral studies: One paper each on oxa-bridged isoxazolidine (NOESY studies), ^{1}H–^{1}H COSEY studies on tautomeric pyrazoles, and X-ray and conformational analysis of bis(benzylidene) cyclohexanone was published. Among the 113 papers published in *IJC(B)* in 2013, as shown in Table 1, there is 1 review paper, 4 papers from abroad, 10 from CSIR laboratories, 2 from IITs, 3 from Central Universities, 4 from private pharma and 90 from state universities and colleges, mostly on the synthesis of heterocyclics.

Analysis of papers published in *JICS* in 2011–2013

This analysis also showed that a large number of papers are from state universities and their affiliated PG colleges (Table 3). Further, there is a large percentage of papers related to heterocyclic products followed by natural products. Most Central institutes/universities have no contribution at all. Some interesting papers can be found in the journal, for example, isolation of arjunolic acid from saw mill waste product from *Termilinia arjuna* and studies on fly ash. Such studies are useful to society if pursued seriously. The contributions of private and pharma are almost nil. Detailed analysis of papers reveals that heterocyclic synthesis dominates the papers published in *JICS* in 2011–2013 (Table 4).

Analysis of papers published in international journals during 2011–2013

Indian research contributed around 2400 papers in international journals of high impact factor (excluding *Science*

Table 3. Papers published in the *Journal of the Indian Chemical Society* during 2011–2013

Year	No. of papers	State universities, including affiliated PG and pharmacy colleges (%)	CSIR laboratories (%)	Central universities/ institutes/IISER, NIPER/BOSE (%)	Private universities (%)	Private pharma (%)	Foreign (%)
2011	55	45 (81)	–	8 (14.54)	–	–	2 (3.63)
2012	43	39 (90.69)	–	2 (4.65)	–	–	2 (4.65)
2013	73	21 (28.76)	5 (6.84)	10 (13.69)	25 (34.25)	3 (4.10)	9 (12.32)

Table 4. Papers published according to sub-areas of organic chemistry in *JICS* 2011–2013

Year	No. of papers	Reviews (%)	Heterocyclic synthesis (%)	Natural products (%)	MISCC./aliphatic/ aromatic compounds (%)	Indian/ private pharma (%)
2011	55	5 (9.09)	23 (41.8)	10 (18.18)	13 (23.63)	2
2012	43	3 (6.97)	22 (51.16)	10 (23.25)	6 (13.95)	2
2013	73	5 (7.46)	42 (55.2)	14 (20.8)	9 (13.4)	3 (4.10)

and *Nature*). The publication of Indian papers in journals like *Journal of the American Chemical Society* (*JACS*), *Angewandte Chemie International Edition*, *Chemical Communication*, *Journal of Organic Chemistry* and *European Journal of Organic Chemistry* is indeed laudable (Table 5). Analysis of the papers published in *JACS* revealed that 12 out of 13 papers are from CSIR laboratories, IISc, and centrally funded institutes and only 1 paper is from state-funded university with overseas collaboration. Out of 84 papers published from India in the *Journal of Organic Chemistry*, only 3 are from state universities and the rest are from CSIR laboratories, central universities and central institutes like IISc, IISER and IITs. In the *European Journal of Chemistry*, 50 papers are from India, out of which 44 are from CSIR laboratories, centrally funded institutes/universities, while 6 are from state universities. The quantum of the papers contributed by state universities is meagre. This aspect needs to be looked at and remedial measures should be taken so that the contribution by state universities of international standard is increased. A closer look at the nature of publications from the Central institutes/universities reveals that these papers are related to synthetic methodologies like recently developed chiral/stereo-specific synthesis involving metal-catalysed asymmetric synthesis, and carbon-cross coupling such as Heck reaction, Sharpless epoxidation, Jacobsen reaction and Suzuki coupling, Grubbs metathesis, click chemistry reactions, etc. Mostly the methodologies are adapted for the synthesis of macrocyclic and macrolids from marine fungi and plant natural products, etc. However, these natural products were not isolated by Indians and their structures were established by spectral methods and two or three independent synthesis by foreign scientists.

With respect to the *Journal of Organic Chemistry*, there were some papers on photocatalysts, fluorescent labelling, glycopeptides and click chemistry, chiral and asymmetric synthesis and C–H-arylation and carbon–carbon cross-coupling. Many papers dealt with metal-catalysed (Pd, Au, Cu, Ag, Zn, Pd–Sn and Mg, Grubbs-catalysed) asymmetric organic synthesis. Of particular interest are 15 papers on natural products synthesis, whose isolation was reported from other countries.

The *Journal of Heterocyclic Chemistry* published 55 papers from India. Among them, universities dominated with 39 papers (70.9%), while 16 papers (24.09%) were from national institutes. A large number of papers (353) are found in *Asian Journal of Chemistry* which has low impact factor (0.25). Table 5 provides the list of publications in international journals and their citation factor. The *Journal of Heterocyclic Communications* has a low impact factor and therefore Indian contributions to it were not counted.

Table 6 lists the research papers published from India during 2011–2013. Generally the contributions from central universities/central funded national institutes like IITs, CSIR, etc. are more compared to state universities. Further, the contribution of Indian scientists in various journals in 2011, 2012 and 2013 is more or less the same (Table 6).

As can been seen from Table 7, in *Synthetic Communications* about 108 papers were contributed by Indian researchers. A greater part of the publications pertains to heterocyclic synthesis (60 papers), natural products (8 papers), synthesis of drugs or impurity profile (5 papers) and rest of the papers are on miscellaneous topics.

Synthesis (56 papers from India) published 19 papers on heterocyclic synthesis, 8 papers on natural products, and the rest on divergent topics. National institutes contributed 39 papers, state universities 13 papers, and private pharma 4 papers with collaboration and only 1 paper exclusively.

The *European Journal of Organic Chemistry* published 50 Indian papers; 45 of these were from the national institutes. Most of these published papers are related to total stereo selective synthesis of natural products,

Table 5. Papers published by Indian chemists in standard international journals and their citation factor in 2013

Journal	Total papers published by Indians	Impact factor
Chemistry of Natural Compounds	10	0.599
Chirality	3	1.894
Current Organic Synthesis	6	2.04
Current Topics in Medicinal Chemistry	15	3.7
Drug Development Research	2	–
European Journal of Medicinal Chemistry	121	3.499
European Journal of Organic Chemistry	50	3.344
Journal of Fluorine Chemistry	10	1.949
Journal of Heterocyclic Chemistry	55	1.224
Journal of Medicinal Chemistry	16	5.614
Journal of Natural Products	5	3.285
Journal of Organic Chemistry	84	4.564
Journal of Pharmaceutical Science	3	3.13
Journal of Physical Organic Chemistry	9	1.578
Synthesis	56	2.542
Tetrahedron Letters	349	2.395
Carbohydrate Polymers	134	3.479
Carbohydrate Research	25	2.044
Chemical Communications (Interdisciplinary papers)	158	6.378
Chemical Reviews	6	41.298
Chemical Science	4	8.314
Chemical Society Reviews	7	24.892
Chemistry, a European Journal	56	5.831
Chemistry, an Asian Journal	25	4.572
Chemistry of Heterocyclic Compounds	3	0.634
Chemistry of Natural Products	10	0.599
Journal of the American Chemical Society (all chemistry papers from Indians included)	13 (multidisciplinary chemistry and biology)	10.677
Tetrahedron	96	2.8
Australian Journal of Chemistry	11	1.869
Beilstein Journal of Organic Chemistry	21	2.801
Biocatalysis and Biotransformation	6	0.895
Bioorganic Chemistry	10	1.732
Bioorganic and Medicinal Chemistry	20	2.903
Biopharmaceutics Drug Disposition	1	2.09
Bulletin of the Chemical Society of Japan	3	1.387
Synlett	45	2.655
Accounts of Chemical Research	2	20.833
ACS Combinatorial Science	4	3.636
Advance Synthesis & Catalysis	17	5.535
Aldrichimica Acta	–	12.231
Angewandte Chemie International Edition	28	13.74
Archiv Der Pharmize	9	1.54
Asian Journal Chemistry	359	0.25
Angewandte Chemie	6	13.74
Bioorganic and Medicinal Chemistry Letters	89	2.338
Journal of Synthetic Organic Chemistry, Japan	0	0.649
Marine Chemistry	04	3.000
Indian Journal of Chemistry (*B*)	113	0.648
Methods in Organic Synthesis	0	–
Molecules: A Journal of Synthetic Chemistry and Natural Product Chemistry	0	2.428
Organic and Biomolecular Chemistry	73	3.568
Organic Letters	76	6.142
Organic Process Research and Development	16	2.739
Phytochemistry	11	3.050
Green Chemistry	28	6.628
Nature (interdisciplinary papers from Indians)	3	38.597
Nature Chemistry (interdisciplinary)	3	21.757
Synthetic Communication	108	1.060
Organic Preparation and Procedures International	14	1.65
Science (interdisciplinary papers from Indians)	4	31.00
Journal of the Indian Chemical Society	73	0.192
Asian Journal of Natural Products	6	0.25

Table 6. Papers published in national and international journals, 2011–2013

Journal	Total no. of publications from India		
	2011	2012	2013
Organic Letters	51	68	76
Journal of Organic Chemistry	77	98	84
Journal of the American Chemical Society	16	12	13
Journal of Natural Products	3	4	5
Indian Journal of Chemistry, Section B	116	114	113
Journal of the Indian Chemical Society	55	43	67

Table 7. Indian papers published in international journals in 2013

Journal	Impact factor	No. of papers	National laboratories/ universities/institutes (%)	State universities and PG colleges (%)	Private universities	Pharma
Journal of the American Chemical Society	10.677	13	12 (92.3)	One with foreign collaboration (0.83)	–	–
Journal of Organic Chemistry	4.564	84	81 (96.4)	3 (3.5)	–	–
European Journal of Organic Chemistry	3.344	50	44 (88)	6 (12)	–	–
Synthesis	2.542	56	39 (69.6)	13 (23.2)	–	Four with foreign collaboration; one with exclusive papers
Journal of Heterocyclic Chemistry	1.224	55	16(29.09)	39(70.9)	–	–
Synthetic Communication	1.224	108	Not analysed institution-wise. These papers pertain to heterocyclic synthesis mainly – 60 (55.5); natural products – 8 (7.4); drug impurity profile – 5 (4.6); rest on divergent topics			

whose isolation was already reported in the literature. State universities published eight papers and there was one contribution from a private university on heterocyclic synthesis in this journal. The contributions of national institutes/universities in high impact journals are high while those from state universities are only handful. Private pharma had only one exclusive paper and private universities had no contribution (Table 7).

Publications in natural products journals, in 2013 (emphasis on isolation and structure determination)

As can be seen from Table 8, *Chemistry of Natural Products* published 10 papers from India. Among them, four are from state universities, one from a private university and five from national institutes.

The *Journal of Natural Products* published 5 papers from India. Among them, 4 are from national institutes and 1 paper is from a state university with foreign collaboration. *Phytochemistry* published 4 Indian papers, out of which 3 were on analytical/fatty acid profile of microalgae and 1 paper on chemo types of a plant. These papers together with the 2013 papers in *IJC*(*B*) and *JICS*, account for 47 papers on phytochemistry from national institutes (50–80%) and state universities (20–40%). Only 2 papers were from private universities and there was no paper from private pharma. India is a tropical country with rich flora and mega biodiversity spots, the Western Ghats and Arunachal Pradesh. During 1960–1980, the Indian contribution in this field was remarkable, but has declined now.

Papers published in medicinal chemistry in 2013

As seen from Table 9, the *Journal of Medicinal Chemistry* (*JMC*), considered as a panorama of research advances in new drug discovery, had 16 papers from India, out of which one was from private pharma on research and development published as an independent paper. Four papers, also from private pharma, had joint publication with foreign pharma laboratories. The rest are from CSIR, especially CSIR–CDRI and IISER. *The Journal of Medicinal Chemistry* lay emphasis on synthesis of large number of compounds, quantifiable evaluation of their

Table 8. Publications of Indian papers in international journals on isolation and structure determination of plant natural products in 2013

Journal	Impact factor	No. of papers	National laboratories/ universities/institutes (%)	State universities and PG colleges (%)	Private universities (%)	Pharma
Chemistry of Natural Products	0.599	10	5 (50)	4 (40)	1 (10)	–
Journal of Natural Products	3.285	5	4 (80)	1 (20)	–	–
Asian Journal of Natural Products	0.25	6	3 (50)	2 (33.3)	1 (16.66)	–
Photochemistry	3.050	4	3* (75)	1 (25)	–	–

Table 9. Papers published on medicinal chemistry in international journals on synthesis, molecular modelling, docking studies and biological activity in 2013

Journal	Impact factor	No. of papers	National laboratories/ universities/ institutes (%)	State universities and PG colleges (%)	Private universities (%)	Private Pharma (%)
Journal of Medicinal Chemistry	5.614	16	11 (68.75)	–	–	Four with foreign collaboration (25); one (6.25) exclusive paper
Bioorganic and Medicinal Chemistry	2.903	20	11 (55)	8 (40)	–	1 (5)
Bioorganic and Medicinal Chemistry Letters	2.338	89	32 (35.9)	41 (46)	8 (8.9)	8 (8.9)

biological activity by testing these compounds, so as to make conclusion on structure-activity relationship (SAR). However, publications in *JMC* are low. A good number of publications are also seen in *Bioorganic and Medicinal Chemistry* (36 papers, impact factor 2.903) and *Bioorganic and Medicinal Chemistry Letters* (98 papers, impact factor 2.338). Their impact factors are low compared to *Journal of Medicinal Chemistry* (5.614). This is the area where considerable publications are expected from private pharma and CROs in India. In this sector according to an estimation about 2000 Ph Ds and 10,000 postgraduates are working on R&D aspects. At least 10% of the staff need to work on new drug discovery with good record of publications. This is happening in the US and Europe. In general, a serious study to discover new drugs is lacking either from national laboratories or private pharma.

Indian publications in research journals on marine chemistry, microbial transformation, fermentation products and antibiotics on national and international journals during 2011–2013

In the field of marine chemistry there are several foreign journals with Indian publications. For example, isolation of uran-2yl acetate from marine streptomycin species in *Natural Products Research* (2011), 4-phenyl-butanoicacid from marine bacterium pumilus in *Biofouling Journal* (2011); a total synthesis of cyclotetrapeptide from marine bacteria in *Marine Drugs* (2011); total synthesis of marine natural product, (+)-Varitrol by novel synthetic methodology in *Organic and Biomolecular Chemistry* (2011), and from a mollusc two new phorbazoles were isolated along with three phorbazoles in *Marine Drugs* (2012). As already pointed out *Journal of Phytochemistry* (2013, Table 8) published 3 papers from national laboratories, one paper from CSIR-Bhavnagar and 2 papers from CSIR-CDRI, Lucknow on analytical profile of microalgae, sea grasses and on marine-sponge.

Isolation of metabolites from fermentation media: Biotransformation in the fermentation media of cholesterol 1,4-androstadiene-3,17-dione by *Nocardia* species isolated from soil of Himalayas – *Annals of Microbiology* (2012); five new secondary matabolites from *Monasas purpureus* fermented from maize grains, *Hirdeum vulgare* and *sorghum vicolor* – *Natural Products Research* (2013).

Antibacterial antibiotics isolation: One aminoindole antibacterial compound having piperazine, 2,5-dione moiety was isolated from the culture medium of *Penicillium chrysogemum* an entophytic fungus on the mangrove plant *Porteriseia coarcotate*. Two stilbenes along with well-known stilbene, resveratrol from cell cultural filtrate of a *Bacillus* sp., strain N bacterium associated with a novel rhabolitid entropahanenes nematode were isolated – *Letters in Applied Microbiology* (2012). In order to get glimpse of the contemporary international research in these fields, the *Journal of Antibiotics* (Japan 2013; impact factor 2.04) was viewed. From this journal at least 15 papers were published on isolation and structure determination of several antibiotics and new natural products; many of them are large molecule complex structures, macrolides, etc. These were reported from fermentation, fungi, etc. from the strains collected from different soils, sediment samples of oceans by foreign scientists. Thus there is wide gap between the Indian and international research.

Subject-wise analysis of sub-areas of organic chemistry and institutions/universities

State universities and affiliated PG colleges

As already pointed out almost all the papers from universities and colleges pertain to synthesis of heterocycles. This is justified given the fact that the universities have meagre funds and the synthesis of heterocycles involves cheap and readily available chemicals. One silver lining in the hybrid heterocyclic synthesis is that 90% of the recently discovered anti-HIV drugs are composed of hybrid heterocyles. Therefore, systematic biological activity of these heterocycles by standard laboratories of CSIR may provide new leads for drug discovery.

There are some aspects in *IJC*(*B*) that need remediation. Nearly 80% of the publications are from state universities and their affiliated colleges and 75% is related to heterocyclic synthesis. For instance it is observed that the discussion on ^{1}H NMR is missing in the text of a paper, though it has been referred in the experimental section. It is desirable to discuss the same in the text, for the benefit of the readers. In some papers of *IJC*(*B*), references for advanced starting materials also not given. The editors and reviewers should concentrate on improving the quality of the publication. We do realize that this is a general short coming in Indian as well as international publications.

Citation factor by Indian papers published in national or international journals need not be taken seriously, since most cited references are found in the first paragraph of the introduction of paper.

A large amount of funds are awarded to CSIR laboratories and Central universities by DST, DBT and CSIR. However, almost all their contributions are being sent to international journals with high impact factor. A strong suggestion is that every scientist of organic chemistry in Central/CSIR laboratories, IITs, need to publish some papers in the *Indian Journal of Chemistry*, and only then the impact factor of *IJC*(*B*), which is a dismal 0.6% at present can be improved. The nodal funding agencies, especially CSIR and others should insist that the recipient institutions publish at least some papers in *IJC*(*B*) thereby increasing its impact factor, which is necessary in the interest of the country. For this purpose, apart from increasing the number of pages in *IJC*(*B*), the acceptance of papers or otherwise may be communicated quickly. The accepted papers may be first published on-line. With the help of the internet, a good paper will reach researchers everywhere, no matter in whatever journal it is published.

For the purpose of awards like CSIR Young Scientist and others, the extent of publication in the *IJC* also needs to be considered. Those giving the awards are only considering the impact factor, which is naturally high for foreign journals. There is a tendency in Central Government laboratories (like CSIR) to consider only international journals for promotions and other administrative posts. This trend needs to be reversed. On the other hand, in state universities for selection/promotion and awards, there is emphasis on teaching ability, although publications are also important. As already pointed out, research grants by state governments are negligible. This is the reason why publications by state universities are confined to heterocyclic synthesis.

Research work on natural products

As already mentioned the Central Government laboratories/industries and Central universities publish several papers on the synthesis of complex marine, fungal and plant natural products, isolated and already synthesized by foreign scientists, using recently developed synthetic methodologies. However, it is desirable that isolation and structure determination of complex natural products from our own flora and fauna be given priority. This area is in dire need of grants for funding research. Mere conversion of a readily available natural product into derivatives or its synthesis in minute amounts does not constitute natural products research. Priority needs to be given for isolation and structure determination, which at one time dominated Indian research and got recognition worldwide during 1970s and 1980s.

In state universities too, at one time isolation and structure determination of plant natural products dominated organic chemistry research. Unfortunately this is not the case at present. The reasons are not clear. In fact, there are several plants in our forests that remain uninvestigated. Moreover, plant research does not need expensive chemicals and spectra could easily be procured from national institutes on payment basis.

Natural products chemists may not be able to publish many papers, by count, but the research status of a scientist needs to be assessed on the basis of the work, especially in Central Government-funded institutes and laboratories. To our knowledge, isolation of antibiotics from microorganisms or from marine sources has not received adequate attention. This area, especially isolation and structure determination of antibiotics by our laboratories needs high priority.

Deemed and private universities

In recent decades many new deemed/private universities (129 and 112 respectively, according to a UGC report 2012) have come up. Although these universities have postgraduate chemistry course, including organic chemistry, publications in research journals are negligible. In fact, only around 20 papers were published by these universities in 2013. There is growing criticism that these private universities are concentrating more on computer

science and engineering faculties while neglecting pure sciences. These are at best glorified engineering colleges charging heavy tuition fees.

Pharmaceutical manufacture sector

A large number of Ph Ds and postgraduates are employed in pharmaceutical R&D, manufacture and custom synthesis. There is no evidence of any basic research activity or new drug discovery. As already pointed above, the number of research papers published by the pharmaceutical R&D in the industry setting is negligible. Their participation in or organizing seminars on the research too is disappointing. The pharmaceutical sector is still importing a huge quantum of chemicals from abroad. About 75% of the chemicals used in the manufacture of drugs is imported from China. Even basic chemicals like glycine, glyoxal, acetonitrile, etc. are being imported from China or other countries. There is no justification to feel proud that we export drugs to some countries while the import component of the chemicals is very high. The patents that these companies produce are by and large tweaks or polymorphs of the established procedures of well-known drugs rather than on new drug discovery. The pharmaceutical sector is receiving huge subsidies and concession from the Government. Their laboratories are also recognized as R&D centres. As such it is expected that they further their research in frontier areas and publish as is the practice in foreign countries. It is a fact that the new drugs from foreign countries emerge only from the pharmaceutical sector (like Merck, Pfizer, SKF, etc.) and they publish papers in all leading journals. The contribution of the Indian pharmaceutical sector in basic research needs to match with CSIR institutions and universities. The planners and policy makers need to think aloud as to why a study of SAR studies of a series of compounds or discovery of new drugs are not forthcoming in India and plan steps to ameliorate the research in India. The publication of research papers in the *Journal of Medicinal Chemistry* is a mirror to indicate our efforts on new drug discovery. This aspect was neglected by national institutes/laboratories and private pharma. It is a fact that state universities have no infrastructure for new drug discovery.

Although our universities have expertise in heterocyclic synthesis, they fail to adopt new methodologies like C–H activation, metal-mediated C–C bond formation and metal-free approaches to construct heterocycles and enhance the impact of the work.

One observation to be noted is that almost all the journals mentioned here are not being subscribed even by CSIR laboratories. Of course, many CSIR laboratories have on-line subscription to these journals, but these are not accessible to junior scientists. What is published by one researcher in a big laboratory is not known his co-scientists. In universities, except Indian journals, no international journals or internet subscriptions are available. That is the reason why *IJC*(*B*) is favoured by state universities and PG colleges. Internet subscription, however, is not a substitute to a library with journals and books.

National institutes/universities/laboratories, including IITs, IISERs and NIPER

It is heartening to note that nearly 90% of papers emanated from central funded laboratories like National institutes, universities, laboratories including IITs, IISERs and NIPERs are publishing in International journals. We are hopeful that the real trendsetting and breakthrough research on discovery of new catalysts (like Grubbs), reagents (simple reagent like Corey's) or new reaction pathways would stem from the Indian research. We still import reagents. Researchers need to synthesize a number of closely related new reagents, without infringing on patents and the work could be published, beneficial for future research. A study of scope and limitation of new reagents would be challenging to our top-level laboratories, and would help in the advancement of chemistry and also get international recognition. Mere publications in international journals of high impact factor adopting recent well-known synthetic methodologies and/or re-synthesis of well-known natural products may not bring adequate credit.

In conclusion, we may have to ponder over the observation of Ali[4], 'In most of our well-funded government research laboratories, research publications, getting Ph Ds and other promotion-based requirements are just fulfilled using unfair means. The quality of research output from such laboratories is poor. In such a scenario, how can we expect miracles in scientific research?'

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