

COLLABORATIONS

Empowering Green Chemists in Ethiopia

Nigist Asfaw,^{1*} Peter Licence,^{1,2} Temechegn Engida,³ Martyn Poliakoff^{2*}

Green Chemistry involves the design and use of less hazardous chemicals and processes (1, 2). Since the early 1990s, it has become increasingly accepted as a promising route to more sustainable production of the chemicals that underpin modern society. Much of the research focuses on the search for renewable feedstocks and more environmentally acceptable solvents to replace petroleum-based products. Thus, Green Chemistry is particularly relevant to the needs of African countries such as Ethiopia, which face an increasing demand for chemicals, little or no indigenous oil, and rapidly expanding populations. However, 4 years ago, the subject was unknown in Ethiopia. Since then, a collaboration that began as a chance meeting has substantially increased awareness. Many Ethiopian chemists now recognize Green Chemistry, and growing interactions are enabling these scientists to organize a conference on the topic for chemists across Africa.

How Can Africa Compete?

In some areas of science, Africa can attract international collaboration on the strength of its natural resources, such as the unique geology of the Rift Valley or the fossils of early hominids in Ethiopia. Very occasionally, an African country has succeeded in building a world-class scientific facility, such as the Southern African Large Telescope (SALT) (see figure, right). More commonly, however, scientists in Africa find themselves in the position of chemists in Ethiopia—a group of enthusiastic and talented researchers striving to establish themselves in a world-wide arena. Scientists across the world have been helping their African counterparts for many years, often with great success. However, it remains crucial that African scientists develop research directions that will attract the interest of other scientists and that they remain compet-

itive in the face of international laboratories with much better resources.

Green Chemistry provides a unique opportunity for African chemists because it combines the search for new science with the development of sustainable chemical technologies appropriate to the needs of the community. Therefore, the resources of Africa—intense sunlight, unique plant species, and enthusiastic young people—provide its chemists with scientific opportunities that are less readily available in many other countries.

The opportunities are clear, but how does one begin to advertise them in a country where they are unknown? Raising awareness of Green Chemistry has been easier than we expected. With modest funding and overseas support, a determined group of Ethiopian scientists has established an international presence within only 4 years. Perhaps this model can be replicated elsewhere.

Ethiopian Green Chemistry: Case Study

Green Chemistry in Ethiopia began with a meeting between Nigist Asfaw (N.A.), a chemistry lecturer at Addis Ababa University, and Martyn Poliakoff (M.P.), a research professor in chemistry at Nottingham, while M.P. was on holiday in Ethiopia. When the meeting took place, N.A. was about to start her independent career and was looking for an appropriate research theme; M.P. is an enthusiastic proponent of Green Chemistry (3). N.A. made a brief visit to Nottingham later in 2003 and obtained U.K. funding for a 3-month stay in 2004. During this stay, N.A. met many U.K. chemists and became a member of the Royal Society of Chemistry (RSC). She also became intrigued by Green Chemistry.

While in Nottingham, N.A. and Pete Licence (P.L.), then a postdoc with M.P., led an investigation on the extraction of essen-

Collaborations between scientists in economically developed countries and their African colleagues can be inspiring and productive.

tial oils from Ethiopian plants with the use of a wide range of milder extraction techniques, including ultrasound, microwaves, and alternative solvents. The subject of their investigation, *Artemisia Afra*, has for many generations been a key ingredient in a wide

variety of traditional medicines used to treat minor ailments ranging from coughs to heart murmurs. N.A. and P.L. found that the oils extracted with the use of milder methods differed considerably in composition from those obtained through traditional hydrodistillation. N.A. brought these results to a major Green Chemistry conference in Germany in October 2004, where she joined the European Union

COST Action D29 in Green and Sustainable Chemistry (4); this made her only the fourth African to participate in any COST activity. The full paper (5) based on her Nottingham work was quickly adopted as teaching material by the New University of Lisbon.

Now working in a new field, N.A. needed the equipment to do these extractions in Ethiopia. By chance, M.P. had noticed a paper in his own field by Endalkachew Sahle-Demessie, an Ethiopian chemist working in the United States. M.P. put him in touch with N.A. and he generously donated a microwave reactor for her to use in Addis Ababa.

Before leaving Nottingham, N.A. decided to run a workshop to begin spreading the message of Green Chemistry in Ethiopia. She invited P.L. to Addis Ababa, and he raised independent funding to cover the cost of the trip and to support the workshop in January 2005. It was a great success, with sessions for academics, industry, and university and high school students (6). The topic really caught people's imagination. The most exciting outcome was the discovery that there were indigenous chemical processes in Ethiopia that satisfied many of

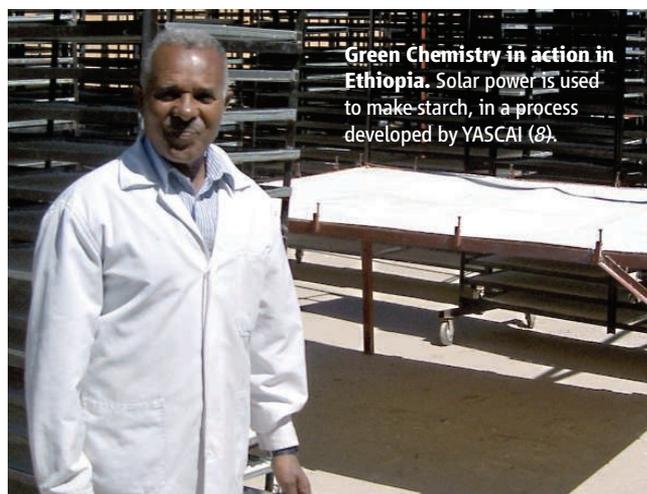


Expertise in astronomy. SALT is a flagship for scientific and technological education and development in Africa (16).

¹Department of Chemistry, Addis Ababa University, Ethiopia. ²The School of Chemistry, The University of Nottingham, Nottingham, NG7 2RD, UK. ³The Federation of African Societies of Chemistry, Addis Ababa University, Ethiopia.

*Authors for correspondence. E-mail: nigista@chem.aau.edu.et (A.N.); martyn.poliakoff@nottingham.ac.uk (M.P.)

the principles of Green Chemistry (7). For example, the rapidly growing chemicals company, Yitbarek Alemu Starch Chemicals and Adhesive Industry (YASCAI), situated on the outskirts of Addis Ababa, extracts high-value performance starches from abundant, easily cultivated regional crops, including enset (false banana) and, most recently, casava. Their process uses locally produced raw materials (biomass, caustic, and mineral acids), minimizing the cost and



environmental impact of transportation of materials (8). Furthermore, energy-intensive drying of the pure starch materials is carried out using free and abundant solar energy (see figure, above). In many applications, their products outperform potato starch imported from overseas.

The workshop provided N.A. with sufficient material to warrant her participation in a major conference on Green Chemistry in Washington, D.C., where she met Paul Anastas, Director of the Green Chemistry Institute of the American Chemical Society (ACS). He paved the way for N.A.'s department to become an External Chapter of the Institute and to raise sufficient funds for a second workshop in Ethiopia. In recognition of his role in the workshop, P.L. was appointed Visiting Professor at Addis Ababa University while still a postdoc in the United Kingdom.

N.A.'s collaboration with Nottingham and contacts within the international community were seen as an opportunity by her colleague, Temechegn Engida (T.E.), who is Vice President of the Chemical Society of Ethiopia (CSE) (9). The CSE was founded in 1982 as the outcome of a United Nations Educational, Scientific and Cultural Organization (UNESCO)-sponsored workshop in Ethiopia. It currently has more than 1200 members, and its journal, *Bulletin of the*

Chemical Society of Ethiopia, is one of the oldest African chemical journals (10). Although the CSE had interacted with other learned societies, it was too small to approach organizations such as the RSC or the ACS on equal footing. It became clear that chemists across Africa should combine to create a critical mass. In 2006, T.E. took the lead in bringing together chemical societies from across Africa to found the Federation of African Societies of Chemistry (FASC) (11). As a result of the Nottingham connection, RSC President Simon Campbell traveled to Addis Ababa for the inaugural meeting of FASC, where he launched the RSC's Archive for Africa. This free archive gives African chemists the same instant access to RSC journals that their colleagues have in developed countries (12). This is important because much of the key literature in chem-

istry is published by learned societies, whose journals are beyond the financial reach of most African scientists.

By fall 2005, P.L. had a faculty position in Nottingham and one of N.A.'s students, Hareg Tadesse, started a Ph.D. under his supervision on a carefully chosen topic. The department at Addis Ababa plans to set up an x-ray diffractometer, and Hareg is being trained in crystallography so that she can return as Ethiopia's first crystallographer, thereby adding to the country's scientific skills. Hareg's second term at Nottingham coincided with the launch of the RSC Archive for Africa, and she was able to express thanks on behalf of all African chemistry students at the U.K. launch ceremony at the Houses of Parliament (13).

The challenge has been to spread the message beyond Addis Ababa University, which has the strongest chemistry department in Ethiopia but is only one of 22 universities in the country. The problem has been the magnitude of the funding needed to extend beyond Addis. Fortunately, in 2006, the British Council, a U.K. government agency with a strong interest in international development, launched a funding scheme, Development Partnerships in Higher Education (DelPHE), targeted at capacity building in developing countries. We were fortunate to secure a grant from their Ethiopian

office, which allows us to start engaging chemists across the country. For example, Bitu Birru, a chemist from Hawassa University, is now trying to functionalize starch samples from YASCAI to make materials for sequestering heavy metals from polluted water.

Implications of the Ethiopian Experience

The profile of Ethiopian chemistry is rising (12, 14), and it is enriching the international scientific community. Green Chemistry has been chosen as the theme of the First Annual FASC Congress in Addis Ababa, September 2007 (11). Our collaboration has been intellectually rewarding for all involved, and it has been particularly helpful in developing the careers of the younger participants. However, this was only possible because our Ethiopian colleagues had already built a strong department at their university.

Other learned societies should follow the lead of the RSC (12) and many commercial publishers (15) in giving free access to their journals to African scientists.

Having overseas scientists to champion their work on the international scene has been valuable to the chemists in Ethiopia. We strongly urge other scientists to build similar relationships on an individual basis in order to articulate better the needs of African scientists in the international arena and to empower these scientists to meet the tremendous challenges of the future.

References and Notes

1. M. Poliakoff, P. Anastas, *Nature* **413**, 257 (2001).
2. M. Poliakoff *et al.*, *Science* **297**, 807 (2002).
3. M. Poliakoff, I. Noda, *Green Chem.* **6**, G37 (2004).
4. Cooperation in the Field of Scientific and Technical Research (COST), see www.cost.esf.org/.
5. N. Asfaw *et al.*, *Green Chem.* **7**, 352 (2005).
6. P. Licence, N. Asfaw, *Green Chem.* **7**, 401 (2005).
7. S. L. Y. Tang *et al.*, *Green Chem.* **7**, 761 (2005).
8. P. Licence, *RSC ESEF Newsl.* **5**, 3 (2005).
9. CSE (www.aau.edu.et/faculties/sc/CSE/home.html).
10. Journal archives are available at www.ajol.info/journal_index.php?jid=120&tran=0&ab=0.
11. FASC (www.faschem.org/).
12. M. Freemantle, *Chem. Eng. News* **2006**, 44 (May 2006).
13. *RSC News* **2006**, 1 (April 2006); www.rsc.org/archivedc.
14. H. Carmichael, *Chem. World* **2006**, 54 (December 2006).
15. For example, see the Health InterNetwork Access to Research Initiative (www.who.int/hinari/about/en/).
16. For a general introduction to SALT, see www.salt.ac.za/.
17. We thank supporters of our collaboration, particularly Endalkachew Sahle-Demessie, Amsalu Abebe, R. Mokaya, S. Poliakoff, and P. Anastas; as well as the British Council, the Engineering and Physical Sciences Research Council, the Royal Society, the Royal Society of Chemistry, the CRYSTAL Faraday Partnership, the Dechema, the U.S. Environmental Protection Agency, the Chemical Society of Ethiopia, the Green Chemistry Institute, the Marie Curie Network Sub Clean ProBiomat, COST Action D29, VSO, Addis Ababa University, and the University of Nottingham.