

Electrochemistry on the internet

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Received: 21 September 2010 / Accepted: 24 October 2010

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Abstract This is a review of electrochemical information and services available on the internet, and some evaluation of their usefulness for professionals, students, and the general public. It seems that we are getting to the point that “if it is not on the internet, it does not exist”. But the question is where to find things and how to know what is reliable and useful and what is not. Some historical notes and personal reminiscences are also included.

Keywords Internet · Electrochemical information · Electrochemical services

Introduction

A search on Google [1] using the term “electrochemistry” results in a listing of over two million webpages. Practically,

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none of this was there 20 years ago—a tremendous change in a short time. But is this change for good? Do those millions of sites and services provide useful information, or are they just “information pollution”? What effect does the internet have on science in general and on electrochemistry in particular? Whatever is the case, this seems to be the wave of the future, so it may be worthwhile to try to shape in the right direction. This article will attempt to suggest some answers and to give a “sample listing” of websites for electrochemists in research, teaching, and outreach-type education.

Internet services

The internet seems to offer two different types of services: information and communication/discussion forums. In providing information, it is similar to the old-fashioned libraries, except in two respects. It provides vastly more information, which is, in most cases, very easily and immediately available to any user around the world, but some of this information may be more questionable in validity. The communication/discussion forums it provides are completely new, there has never been a possibility for such wide-ranging (practically covering the world) and almost instantaneous exchange of ideas.

It is interesting to examine how these technologies serve three types of users: professional electrochemical scientists/engineers who are actively practicing in the field, students of electrochemistry or science/engineering in general, and the general public who are curious about electrochemical topics.

Professional users

Information (library) services

The professional use of the library function of the internet is very widespread: every journal worth its salt is now available on the internet (many of them back to their first

volume), and lately, more and more books are also available in digital format. These are typically available only on subscription basis, mostly through university and research institution libraries, and that is how they are used. Many libraries now subscribe only to the digital versions, paper versions of present journals are often not available, and older volumes are either hidden in storage somewhere or were already discarded. If you ask for them in your library, they will probably tell you to go to the internet. Libraries are shrinking both in physical sizes of their collections and in the volume of hard-copy users, especially among the younger generation. Slowly, the libraries are becoming only a portal to the internet. It is getting there pretty soon: if it is not on the internet, it does not exist. For example, the proceedings, abstracts, extended abstracts, and meeting programs for recent scientific meetings are increasingly published only in digital form; for the older meetings, unfortunately, this information is only very slowly (if at all) digitized.

It is interesting how differently journals and books are treated. Many, if not most, journals are now available on the internet (largely through your library's subscription) from today's issues back to volume one (even if that was 200 years ago), and some of the recently started journals are available only on the internet—see, for example, some historical papers in electrochemistry [2]. Books are different. Many old books (up to about the 1920s) are widely and freely available on the internet to anyone [3], and the latest books (published during the last 5 to 10 years) are increasingly available in digital form, but only on a subscription basis. Very few are available from the books published in between, some for a price. All this is justified by copyright laws.

But where can professionals look for relevant information outside their own library? If you are looking for books, proceedings, and journals, one very large searchable listing of hard-copy information is WorldCat [4], which supposedly has access to almost all library catalogs around the world. Digitized versions of many of the same items can be found in two sources: in an internet archive of old books and journals [5] and in a European digital library [6]. These archives are building a digital library of internet sites and other cultural artifacts in digital form. Like a paper library, they provide free access to researchers, historians, scholars, and the general public. These sources are, of course, completely general, covering not only electrochemistry but all other sciences, and also all other literature ever published. It may take a considerable amount of searching to find the appropriate information. There is one site, the Electrochemical Science and Technology Information Resource (ESTIR) [7], which contains much of the electrochemistry-related information already extracted from the above general sources, and it contains also some other information useful for professionals (societies, meetings, graduate school

directory, listings of nomenclatures and standards, etc.), and a large collection of links to websites of interest possibly for professionals, and certainly for students and the general public. Other areas on the internet where professionals can find useful information are the websites of universities and scientific societies. A very good collection of links to Chemistry Departments all around the world can be found at the website of the Department of Chemistry, University of Cambridge [8] and for departments specifically involved in electrochemistry, in the graduate school directory of ESTIR [9]. Societies of most interest to electrochemists are probably ECS [10] and ISE [11], and links to many others are also available [12].

Searching for information

Searching for information in the scientific literature is now completely computerized. It is probably fair to say that practically nobody is using the Chemical Abstract's thick decimal and annual indices anymore. Numerous services are available on the internet, at a price, for such searches at a fraction of the time and effort it used to take in the old days.

Professional-level information outside the scientific literature is somewhat harder to find. How do general search engines serve the professional group? Let us take Google [1] as an example, being the most popular. Of the two million plus sites found when searching for “electrochemistry”, in the first one hundred sites (few people look further than that), there is a very meager sampling of electrochemically related societies, journals, and books. Google supposedly lists the sites in order of “importance”, mainly based on how many other sites link to it. Apparently, this does not work very well for the professional group, maybe because they do not create the majority of the sites where they would provide links to sites they consider important and informative. Another type of sorting is provided by Xmarks, according to the number of “bookmarks” a site has in people's computers [13]; this is even worse, listing only one society and no journals among the “most important” sites.

It seems that the professional group is very well served by the internet's library function; it is very convenient and practical to have a large part of the library (journals, proceedings, and some books) at their fingertips, in the privacy of their office. This service is still growing and is becoming more and more practical and easy to use. On the other hand, searching the internet (outside what is already available through their institutions' library) is probably the most profitable if they are looking for some information completely outside their own field. One exception may be teachers of general science and who want more specific information sources on electrochemistry for their students (see below).

Communication/networking services

The situation is different on the communication/discussion area. Email itself, email lists, newsgroups, networking, blogs, etc. have been used somewhat one-sidedly in electrochemistry, they have been fairly successful in the past as “ask-an-electrochemist” type of service, non-electrochemists asking questions and electrochemists providing information. There were a number of such email lists and newsgroups on electrochemical topics, most of them are not operating anymore or are overrun by spam— see, for example, “sci.chem.electrochem” [14]. For some reason, these never developed into professional discussion forums on serious scientific/technological topics, and there are no active newsgroups or networks presently serving the professional electrochemist.

There is one major, very widely used and very convenient aspect of these new communication possibilities: the submission and refereeing of journal articles, almost completely done digitally nowadays. Another, relatively new, area is the electronic meetings and “webinars” provided by a number of outfits. Presently, they seem to be mainly used in business and marketing, but they certainly have possible applications in electrochemistry.

Student and general public users

The usage patterns of students and the general public probably overlap to a considerable extent. Starting with high-school and certainly undergraduate and beginning graduate students, they can find much useful information about their scientific interest, in this case, electrochemistry, in the popular websites and, as their understanding of the subject grows increasingly in the professional sites, these users will typically not use a library as an intermediary but will go directly to the internet, and especially will use the search engines.

If you search the internet, you will find at least a dozen or two very informative popular information sites on the first few pages if you search for “electrochemistry” in general and also if you look for specific topics, say “fuel cells”. Many of these sites will attempt to explain the topic in simple language, without using too much “jargon”. Others are introductory or elementary treatments, suitable for students. None of this is probably of any use for the professional in the field. I will attempt to give a sampling of the sites treating electrochemistry in general. A number of more good sites can be found for specific, narrower topics.

There are quite a number of sites that are in-between in style and content of professional and popular, some rather extensive introductory textbooks and lecture notes, for

example [15–17] and general informational sites, for example [18–20] (all somewhat randomly selected) would be of no interest to the practicing electrochemist, and are too complicated for the general public; these serve students well.

For general information, the mother of them all is Wikipedia [21]; it has over 150 entries treating in some detail a large variety of electrochemistry topics. The problem with this site is the question of reliability. The authors are anonymous, and probably numerous for any entry since any user can edit, add, make changes, “if you do not agree, change it”, and of course, somebody can change it back again. The basic idea is that this kind of “communal” knowledge will arrive at the truth eventually, maybe in the long run. The problem probably is that people most knowledgeable about the subject will not bother to get involved. The reliability of information is, of course, always questionable, but isn’t this also the case if you go to any library and pick up a book randomly? It always helps if the source is clearly identified—one will be more trusting if a professor writes lecture notes for students, and the writer and the institution are identified.

The average citizen may be looking for simple explanation of some topics (like what are those “batteries” and “fuel cells” everybody is talking about and soon may be in my car?), and they do not want to pay for it. These users are very well served by the search services, but there are two problems: many of the sites contain too much scientific/technical jargon, making them difficult to understand, and the reliability of information is always questionable. The “Electrochemistry Encyclopedia” [22], containing articles on dozens of topics, attempts to overcome these problems, the articles are written by internationally known experts in the field in a “popular-science style”, and the unavoidably used occasional scientific terms are explained in the interlinked “Electrochemistry Dictionary” [23] containing over 1,000 simple definitions. Among the specific topic sites, let’s just mention one battery [24] and one fuel cell [25] site.

There are also some “index” sites which do not provide specific information about the subject but give a list of information sources. Two examples are the “Internetchemistry” site [26] and the “Electrochemical Science and Technology Information Resource (ESTIR)”, which lists over 1,000 links to electrochemistry-related sites [7].

It seems that search engines will generally serve the student users the best; they will easily find a number of elementary textbooks and many popular or semi-popular sites for a large variety of topics. The general public is also served reasonably well, but the search results will never indicate how simply written and reliable a site is.

The communication/networking aspects of the internet are probably not very relevant for students and the general public, specifically for electrochemistry. What is missing

for these users is a good, reliable, and moderated “ask-an-electrochemist” site, which, as mentioned above, is not in useful operation anymore.

Some historical notes and personal reminiscences

To close, I include some of my involvement in the early spread of electrochemistry on the internet. This is also an interesting demonstration of the very international nature even of the early “World Wide Web”. Early in 1994, I took a short course on the use of “newsreaders”. I was working then at Argonne National Laboratory, and being interested in computers and their uses, I took many courses offered by the Computer Division. It was then that I learned about the existence of USENET/NETNEWS and their “newsgroups”, and that this service is available through the Argonne computer system. I found and immediately subscribed to the chemistry newsgroup SCI.CHEM. There were not many daily postings, but it so happened that practically the first week, a posting appeared from James P. Moran of Canada asking whether anybody would be interested in starting an electrochemistry-related subgroup. Two of us raised our hands (virtually speaking)—Lachlan Cranswick from Australia and myself from the USA. Lachlan was not an electrochemist, he was an x-ray crystallographer, but he had some connections to electrochemists at his work and he had experience in starting a newsgroup being involved somewhat earlier with a crystallography group. It was not a simple procedure in those days to start a newsgroup, a formal proposal was required, together with a proposed Charter of the group, these were submitted for a discussion and finally, for a vote among all other newsgroups that may be affected. To quote just a few sentences from a rather lengthy document I still have on file: “GUIDELINES FOR USENET GROUP CREATION”

“A request for discussion on creation of a new newsgroup should be posted to news.announce.newgroups, and also to any other groups or mailing lists at all related to the proposed topic if desired.”

“AFTER the discussion period, if it has been determined that a new group is really desired, a name and charter are agreed upon, and it has been determined whether the group will be moderated and if so who will moderate it, a call for votes may be posted to news.announce.newgroups and any other groups or mailing lists that the original request for discussion might have been posted to.”

“The voting period should last for at least 21 days and no more than 31 days, no matter what the preliminary results of the vote are.”

“AFTER the waiting period, and if there were no serious objections that might invalidate the vote, and if 100 more valid YES/create votes are received than NO/don't create AND at least 2/3 of the total number of valid votes received are in favor of creation, a newgroup control message may be sent out.”

Well, we did all that, and “There were 284 YES votes and 12 NO votes, for a total of 296 valid votes. There was 1 abstain.” I still have the list of all the voters. By the end of April 1994, the new group SCI.CHEM.ELECTROCHEM [14] was launched on USENET.

At that time, “newsreader” services were not generally and easily available to everybody, while e-mail was already widely used. It seemed appropriate to generate an e-mail-list service and transfer the postings back-and-forth between the newsgroup and the mailing list. Being at a government laboratory, I could not start a mailing list, and I asked for volunteers. Otavio Bottecchia from Brazil was willing to set-up the mailing list at his university, and it was launched in June of 1994 as ELETQM-L. I was doing the transfers between the two services until early 2002. That time, I retired from Argonne and was planning to spend considerable time under circumstances when the internet would not be available for me. So, I was again asking for volunteers. The international circle was closed, I found a volunteer in Canada where the original suggestion for the group came from, Rudolf Potucek, who at that time was a graduate student of Viola Birss. He continued the transfer service for a time until it was obvious that it is not needed anymore since newsreader services became widely available. The mailing list ELETQM-L is no longer in operation, but the newsgroups SCI.CHEM.ELECTROCHEM [14] and a later launched subgroup SCI.CHEM.ELECTROCHEM.BATTERY [27] are still available. Unfortunately, during the last 2 years or so, they became completely useless, because, being non-moderated, they were overrun by spam. The posting load was never very heavy, typically several posts weekly, generally questions by nonelectrochemists about batteries, fuel cells, electroplating, etc. These were generally answered by electrochemists. So, in effect, they were something like an “ask-an-electrochemist” service, and in that role, they probably served a good purpose. For some reason, they were never used as a discussion forum amongst professionals.

There were some other outgrowths of these efforts. It was popular at that time for newsgroups and mailing lists to have a “Frequently Asked Questions (FAQ)” file, which was periodically revised and posted. I had written one later in 1994, including a variety of general information about electrochemistry. As a matter of fact, this FAQ is still kept

updated and is available in three parts [28–30]. In 1995, I used the information in the FAQ file to start a website “Electrochemical Science and Technology Information Resource (ESTIR)” [7], which was, for a short time, on an Argonne computer and later moved to the Ernest B. Yeager Center for Electrochemical Sciences (YCES) at Case Western Reserve University. The “Electrochemistry Dictionary” [23] was added in 1999, and the “Electrochemistry Encyclopedia” [22], in 2001.

Concluding remarks and future trends

It seems that professional electrochemists are very well served by the internet’s library function; it is very convenient and practical to have a large part of the university library (journals and recent books and proceedings) at their fingertips, together with the new communication possibilities in the submission and refereeing of journal articles which is almost completely done digitally nowadays. This library service will continue to grow until probably all new publications will be available only on the internet and, hopefully, all old publications will also be digitized. However, in the communication/networking area, the results are less positive. For some reason, email lists/newsgroups never developed into professional discussion forums on serious scientific/technological topics, and presently, there is no network dedicated to electrochemists. “Webinars” and other electronic meeting formats are starting to be used, and this will probably increase for some small meetings. It is very doubtful that large scientific meetings will ever be conducted on the internet. Just like the LP did not replace the concert hall, the TV and later the tape and the DVD did not replace the movie theaters. The personal contact aspects and social contents cannot be digitized.

The information (library) services work very well also for the student users and the general public. The usage patterns and interests of these two groups are much intertwined, while the more advanced students use the same services as the professionals. Many good information sources are available and can be found through search engines, with one caveat: consider the source to judge the reliability. What communication service is presently missing for these users is a good, reliable “ask-an-electrochemist” type site. Such a service and a reliable but still simple, all-inclusive outreach-type educational effort are too large tasks to be carried out by individuals. These could be provided, but presently are not, by large scientific societies together with a

specialized information exchange site and networking for professionals.

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