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*Information sources for electrochemistry**

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The many types of information sources available for electrochemists are reviewed. The primary literature of electrochemistry and the role of the secondary literature in providing access to the primary are described. The complementary natures of the many databases that contain information on electrochemistry are emphasized.

1. Introduction

Effective searching of the technical literature is every bit as important a skill for researchers in electrochemistry as is the capability to assemble and apply the instrumentation in the laboratory. A crucial preliminary to the planning and carrying out of any research project, whether of a fundamental theoretical nature or in some applied technological area, such as the development of a fuel cell or of some electrolytic process, is the literature search to review the results of prior investigations and the descriptions of experimental procedures that have been developed.

The technical literature falls into two major categories: *primary* – journal articles, reports, reviews, books, and patent specifications; and *secondary* – the familiar abstract journals and other types of alerting services that direct to the information appearing in the primary literature. While the printed secondary sources are likely to be the most familiar type for many electrochemists, the computer-based online files are establishing themselves as dominant resources for effective and rapid searching.

2. Primary technical literature

Some 9000 serial publications devoted to science and technology are published in the USA every year. About half of these are basic research journals, the others being trade journals, popular publications, etc. It has been estimated that scientists and engineers in the USA spend 240 million hours each year reading the technical literature, a per capita average of nearly 70 hours [1–3].

The technical publications of interest to chemists produced throughout the world number about 13 000, i.e. those that are routinely monitored by the Chemical Abstracts Service. While a large proportion of these are, of course, chemical in a strict sense, there is considerable overlap into the neighbouring disciplines of physics, engineering, biology and medicine. The common denominator is a concern for materials, their properties and their interactions, which are the domains of the chemist as broadly defined. Despite the imposing number of publications from which papers are selected, it is a striking fact that 50% of the abstracts that appear in *Chemical Abstracts* (*CA*) refer to papers that are published in fewer than 500 journals [4]. In 1984 *CA* published more than 460 000 abstracts of journal papers, patent documents, books, technical reports and reviews. Additional citations were given to some 111 000 patent equivalents (i.e. patent documents that correspond to specifications previously abstracted, usually because of prior filing in another country) [5]. Over 60% of the chemical papers are published in the English language.

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Hawkins [6] estimated that there are 3500 primary journals that publish papers relating to electrochemistry. But just 10 of these journals publish 50% of all such papers, while 31 publish 75%. Furthermore, only 22 journals devote as much as half of their contents to electrochemistry. In terms of the proportion of electrochemical papers published, Hawkins gave the highest ranking to the *Journal of Applied Electrochemistry* (at about 93%). In absolute terms, however, this journal published fewer than one-tenth of the number of papers that appeared in *Elektrokhimiya*, which proportionately ranked third (at just over 90%). The *Journal of the Electrochemical Society* ranked 23rd (at a little over 50%), a reflection of the considerable numbers of papers in areas not regarded by Hawkins as electrochemical, i.e. ceramics, metallurgy and semiconductor technology.

Monitoring of the many thousands of papers, patents, etc. that appear each year in the field of electrochemistry alone places a considerable burden on the researcher. Since much of the literature is in languages other than English, and many electrochemical papers appear in journals that are relatively obscure and difficult to obtain, the problem of remaining abreast of research and technology worldwide is magnified.

Although the texts of a number of the primary journals are available for online display, this is not as yet widespread. The eventual demise of the primary journals in their printed form has been predicted by some, but for most of us in the technical community the printed page will remain for the foreseeable future the means by which we consult the technical literature.

3. Secondary literature

Ready access to the large amount of primary technical literature is provided by the *secondary* services. These services make information available in a variety of forms, i.e. print, microform and computer-readable magnetic tape. Secondary publications range from simply-arranged alerting bulletins, such as those that are based on titles alone, to highly organized abstract journals with elaborate means of indexing and cross-indexing.

Table 1 lists the major abstract journals that contain significant amounts of information on one or another of the many aspects of electrochemistry, running from electrolytic syntheses, electrophoretic separations and electroanalysis, through batteries and fuel cells, to process and corrosion engineering. (Further information on the various secondary services and their products can be found in the sources cited in [7–9].) As their titles indicate, the orientations of these journals vary widely. While there is considerable overlap in subject coverage from one to another, as a group they complement one other so as to encompass the many varied interests of electrochemists.

Individual issues of the abstract journals are organized by topics of major interest. For example, abstracts in *Engineering Index* appear under many subject headings, such as 'Aluminum and Alloys', 'Electrolytic Cells', 'Electroplating', and 'Storage Batteries'. In *CA*, on the other hand, abstracts are divided among 80 sections of broad subject interest, e.g. 'Electrochemistry' (Section 72), 'Electrochemical, Radiational and Thermal Energy Technology' (Section 52), 'Ferrous Metals and Alloys' (Section 55), and 'Nonferrous Metals and Alloys' (Section 56).

Various types of indexes to, e.g. subjects, author names and patent identifications appear in the abstract issues, providing ease of access to the abstracts with their bibliographic data. More extensive indexes are commonly compiled semiannually or annually, and also in some cases for multiyear periods (e.g. the *CA* Collective Indexes, which appear every five years).

Author indexes give the names of individual authors of papers and of inventors in the patent literature. And they might also include corporate sources (industrial concerns, governmental agencies, research institutes, etc.) and patent assignees. Such indexes are useful for the researcher who is attempting to follow the work of a particular author (or group of authors) or that being pursued by a particular company or laboratory.

Keyword indexes furnish information on subject content but are not 'in-depth', i.e. they tend not to be highly detailed. Such indexes may include listings of isolated terms or they may involve term co-occurrences or in-context phrases. They might be in the form of loosely

Table 1. Abstract journals

Title	*Publisher**	*Comments on content*
Atomindex	INIS	Chemical, material, energy topics
BNF Abstracts	BNF	Nonferrous metallurgy
Central Patents Index	Derwent	Chemical patents
Ceramic Abstracts	ACS	Ceramics, electrical materials
Chemical Abstracts	CAS	Chemistry, related disciplines
Chemical Engineering Abstracts	RSC	Electrochemical topics
Corrosion Abstracts	NACE	Corrosion engineering
Corrosion Control Abstracts	SIC	Translation of Russian-language journal
Current Abstracts of Chemistry and Index Chemicus	ISI	Organic syntheses, reactions
Electrical and Electronics Abstracts	INSPEC	Electrical materials, power systems
Electrical Patents Index	Derwent	Electrical, electronic patents
Energy Abstracts	Ei	Electrochemical topics
Energy Information Abstracts	EIC	Electric power, solar energy
Energy Research Abstracts	DOE	Reports from DOE, other US federal agencies
Engineering Index	Ei	Engineering, materials
Government Reports Announcements and Index	NTIS	Reports from US federally funded research; chemical, electrical, energy topics
Metals Abstracts	MI	Metal science, metallurgy
Physics Abstracts	INSPEC	Chemical, electrical, energy topics
Referativnii Zhurnal	VINITI	Chemical, engineering topics
Scientific and Technical Aerospace Reports	NASA	Chemical, electrical topics
Solid State Abstracts	CSA	Chemical, metallurgical topics
World Aluminum Abstracts	MI	Aluminum metallurgy

* For this and subsequent tables, publishers and database producers are identified more completely in the Appendix.

structured, unarticulated associations of terms, or of articulated phrases (as from journal titles). Keyword indexes are useful for rapid scanning of the contents for subjects of interest.

What are here referred to as *subject indexes* are more highly structured, with substantially greater detail than the keyword indexes. These indexes usually have some degree of vocabulary control, such as index headings selected from predetermined classifications (or thesauri) or derived from systematic nomenclature schemes that govern the naming of compounds. Synonyms and related terms are linked by means of cross-references that provide consistency of terminology and therefore ease of searching. Indexes of this type are customarily used for retrospective searching, i.e. examination of the older literature as distinct from the current material.

There are also various types of specialized indexes, such as those for patent, report and contract numbers. *Patent indexes* are organized by means of the issuing nations (or of international groups such as the European Patent Organization and the World Intellectual Property Organization). Elaborate cross-reference schemes correlate those patents that are filed in and/or issued by different countries, as well as divisions, continuations in part, etc. Indexes of report and contract numbers pertain for the most part to sponsored research, frequently carried out with governmental support. These indexes aid the searcher in following that extensive research that might appear only in the patent or report literature, or might be published in the technical journals only at some later date.

Formula indexes are especially valuable for locating information on chemical compounds by those searchers who are not fluent in the sometimes subtle and intricate principles of chemical nomenclature. Chemical terminology can vary so much from one database to another that formula indexes might on occasion serve as the sole means for locating information on particular compounds of interest.

Associated with many of the major abstract journals are current-awareness publications, more limited in the scope of topics and the extent

Table 2. Current-awareness bulletins

Title	*Publisher*
Title-based	
Chemical Titles	CAS
Current Contents	ISI
Current Papers	INSPEC
NTIS Title Index	NTIS
WPI Gazettes	Derwent
Abstract-based	
CA Selects	CAS
Analytical electrochemistry	
Batteries and fuel cells	
Corrosion	
Electrochemical organic synthesis	
Electrochemical reactions	
Electrodeposition	
Energy reviews and books	
Central Patents Index Alerting Bulletins	Derwent
Energy Updates	DOE
Metals Digests	MI
Cleaning/finishing/coating	
Corrosion prevention/inhibition	
Titanium	
New technology	
NTIS Abstract Newsletters	NTIS
Chemistry	
Energy	
Manufacturing technology	
Materials science	
Technical Bulletins	Ei
Ceramics	
Corrosion protection	
Superalloys	

of the primary literature that are covered. These bulletins are commonly 'spin-offs' from the parent journals and are directed toward the interests of workers in certain rather narrow areas of research. They may rely just on document titles or may include abstracts as well. Certain current-awareness bulletins that contain information useful for electrochemists are listed in Table 2. Some of the 'title-only' bulletins appear in a permuted (or rotated) keyword-in-context (KWIC) format, in which each significant word of a document title is highlighted by alphabetical positioning. A quite different arrangement is, however, used for ISI's *Current Contents* series, which reproduces directly the title pages of principal journals in the various subject area. Keyword and author indexes are included with some of these bulletins.

4. Computer-readable databases and online search services

The most familiar of the information sources for many researchers are those that appear in print, mainly the abstract journals. But to an ever-increasing extent, retrieval of information now relies on the computer-based databases. Nearly all of the abstract journals included in Table 1 have one or more computer-readable magnetic-tape files associated with them. Table 3 presents a list of many of the online files that are of value to electrochemists, including some that have no counterparts in the form of printed abstract journals. The computer-readable files might contain either selected segments or essentially all of the information that appears in the printed versions. COMPENDEX and METADEX, for example, include the abstract texts that appear in their counterparts in print, as well as the bibliographic and index data. CA SEARCH includes bibliographic and index data but no abstracts, while CA FILE, one of the CAS ONLINE files, has the abstract texts in addition.

The power of the computer to process rapidly enormous amounts of information makes it feasible to select and format the data for the tape files in a variety of ways so as to facilitate machine searching by means of various approaches and through many different points of access. Searching via the online databases has added a powerful dimension to information retrieval. Use of the computer permits effective and rapid correlation of many different search terms at a level that might not be practicable by older manual means.The searcher can frame a query that could, for example, retrieve relevant information on patents concerned with fuel cells that utilize certain materials, issued in a particular time period to some multinational industrial concern; retrievals could further be restricted to one or more languages and/or countries of origin. An effective strategy can retrieve citations of a high degree of both precision and relevancy, leading to greater economy in the effort expended in searching of the literature. Such a capability has value not only for retrospective searching, but can also serve for ongoing current-awareness alerting. Individualized search profiles (i.e. collections of terms that

Table 3. Computer-readable databases

Title	*Producer*	*Comments on content*
BNF Metals	BNF	Corresponds to *BNF Abstracts*
CA SEARCH; CAS ONLINE	CAS	Correspond to *Chemical Abstracts*
Ceramic Abstracts	ACS	Corresponds to publication
Chemical Engineering Abstracts	RSC	Corresponds to publication
CLAIMS	IFI/Plenum	US chemical and electrical patents
COMPENDEX	Ei	Corresponds to *Engineering Index*
CORROSION	Dekker	Corresponds to *Corrosion Resistance Tables*
DECHEMA	DECHEMA	Chemical engineering, corrosion
ENERGY	DOE	Citations from *Energy Research Abstracts, Atomindex*
ENERGYLINE	EIC	Corresponds to *Energy Information Abstracts*
INDEX CHEMICUS ONLINE	ISI	Corresponds to publication
INIS	INIS	Corresponds to *Atomindex*
INPADOC	INPADOC	Patent literature
INSPEC	INSPEC	Citations from *Electrical and Electronics Abstracts, Physics Abstracts*
METADEX	MI	Corresponds to *Metals Abstracts* and *Alloys Index*
NTIS	NTIS	Citations from *Government Reports Announcements and Index*
PASCAL	CNRS	Chemistry, metallurgy, engineering
SCISEARCH	ISI	Citations from *Science Citation Index, Current Contents*
World Aluminum Abstracts	MI	Corresponds to publication
World Patents Index (WPI)	Derwent	Citations from *Central Patents Index, Electrical Patents Index*

define the subjects of interest, interlinked by means of operators that specify the logical associations among them) can be run on a regular basis against periodic additions to one or more of the databases that are potentially of value. This provides a convenient means of alerting to the newly published literature in specialized areas.

Research organizations commonly employ in their library facilities staff members who are trained for online searching and attain experience in those databases that are useful for the particular interests of the research groups. Many researchers, however, are now finding it advantageous to carry out their own searching, perhaps via personal computers; for them, familiarity with the characteristics and contents of those databases that might be expected to provide useful information on a particular topic is vital to effective retrieval. And for those (the 'end users') who continue to rely for their searching on the professional librarians, who might in turn have limited knowledge in the technical aspects of electrochemistry, an awareness of these resources that are most promising will establish more solid bases for the development of search profiles that can produce retrievals of relevance.

Computer-readable databases are, for the most part, made available to searchers through commercial host systems, rather than directly by the database producers. Some examples of major online hosts that provide access to files containing information useful for electrochemists are Bibliographic Retrieval Services (BRS), Data-Star, Dialog Information Services, European Space Agency Information Retrieval Service (ESA-IRS), INKA, Pergamon Infoline, STN International, System Development Corporation (SDC ORBIT), and Télésystèmes-Questel. In addition, there are search systems that serve clients primarily within particular nations. A few examples of these are the following:

Canada Institute for Scientific and Technical Information, National Research Council, Ottawa, Canada.

Centre National de l'Information Chimique, Paris, France.

Chemie-Information und Dokumentation Berlin, German Chemical Society, Berlin, Federal Republic of Germany.

Japan Information Center of Science and Technology, Tokyo, Japan.

Royal Society of Chemistry, Information Services, Nottingham, UK.

Table 4. Information and data centres

Centre	*Information*
Alloy Data Center, National Bureau of Standards, Washington, DC, USA	Phase diagrams, physical properties of metallic systems
Center for Information and Numerical Data Analysis and Synthesis, Purdue University, West Lafayette, IN, USA	Electronic, magnetic, optical, thermophysical properties
Mechanical Properties Data Center, Battelle Memorial Institute, Columbus, OH, USA	Properties of metals and alloys, corrosion data
Metals Data Centre, National Research Council, Ottawa, Canada	Crystallographic data on metals and intermetallic phases
Zentralstelle Dokumentation Elektrotechnik, Fachinformationszentrum Technik, Frankfurt am Main, Federal Republic of Germany	Electrochemistry, engineering

5. Information centres

Another type of information source is the information or data centre, which specializes mainly in topics of rather narrow interest. Typically these centres include in their collections material that is derived not only from the open literature but also from technical reports of limited availability, perhaps classified or proprietary. Some of them issue current-awareness bulletins, monographs, bibliographies, reviews and compilations of numerical data, which might have been critically evaluated, as well as providing custom searching. Access to the holdings of certain centres is restricted to sponsoring groups, such as members of trade organizations or industrial consortia or to governmental agencies and their contractors. A few representative centres that handle information pertaining to various aspects of electrochemistry are listed in Table 4.

7. Summary

A wide variety of information sources useful for the electrochemist is available in printed, microform and computer-readable formats. An array of complementary secondary sources greatly expands the resources available for the aid of the researcher.

The abstract publications are probably the most familiar types for most electrochemists. However, computer-based search systems, which provide access to many cross-disciplinary online databases, have established themselves as important tools for information retrieval. Machine searching might be conducted through the offices of the trained information specialist, who is familiar with the contents and command languages of the many available databases as well as their relative merits for answering the types of queries that are posed. Alternatively, searches might be conducted directly by the researcher, who must then acquire the skills necessary to devise the strategies and carry out the manipulations involved in effective searching of the technical literature.

Appendix

Key to secondary-journal publishers and database producers

ACS	American Ceramic Society, Columbus, OH, USA
BNF	BNF Metals Technology Centre, Wantage, UK
CAS	Chemical Abstracts Service (a Division of the American Chemical Society), Columbus, OH, USA
CNRS	Centre National de la Recherche Scientifique, Centre de Documentation Scientifique et Technique, Paris, France
CSA	Cambridge Scientific Abstracts, Bethesda, MD, USA

DECHEMA	Deutsche Gesellschaft für Chemisches Apparatewesen, Informationssystem Chemische Technik, Frankfurt am Main, Federal Republic of Germany
Dekker	Marcel Dekker, Inc., New York, NY, USA
Derwent	Derwent Publications Ltd., London, UK
DOE	US Department of Energy, Technical Information Center, Oak Ridge, TN, USA
Ei	Engineering Information, Inc., New York, NY, USA
EIC	EIC/Intelligence, Inc., New York, NY, USA
IFI/Plenum	IFI/Plenum Data Co., Alexandria, VA, USA
INIS	International Atomic Energy Agency, International Nuclear Information System, Vienna, Austria
INKA	Fachinformationszentrum Energie, Physik, Mathematik GmbH, Karlsruhe, Federal Republic of Germany
INPADOC	International Patent Documentation Center, Vienna, Austria
INSPEC	Institution of Electrical Engineers, Hitchin, UK
ISI	Institute for Scientific Information, Philadelphia, PA, USA
MI	Metals Information, American Society for Metals, Metals Park, OH, USA, and the Metals Society, London, UK
NACE	National Association of Corrosion Engineers, Houston, TX, USA
NASA	US National Aeronautics and Space Administration, Scientific and Technical Information Branch, Washington, DC, USA
NTIS	US Department of Commerce, National Technical Information Service, Springfield, VA, USA
RSC	Royal Society of Chemistry, Nottingham, UK
SIC	Scientific Information Consultants, London, UK
VINITI	USSR Academy of Sciences, Moscow, USSR

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