

---

# Non-Aqueous Electrolytes for Lithium Batteries

---

## Editors:

### **T. R. Jow**

U.S. Army Research Laboratory  
Adelphi, Maryland, USA

### **W. Henderson**

North Carolina State University  
Raleigh, North Carolina, USA

### **B. Lucht**

University of Rhode Island  
Kingston, Rhode Island, USA

### **M. Ue**

Mitsubishi Chemical Corporation  
Yokohama, Japan

## Sponsoring Divisions:



Published by

**The Electrochemical Society**

65 South Main Street, Building D  
Pennington, NJ 08534-2839, USA

tel 609 737 1902

fax 609 737 2743

[www.electrochem.org](http://www.electrochem.org)

**ecs**transactions™

**Vol. 16 No. 35**

---

Copyright 2009 by The Electrochemical Society.  
All rights reserved.

This book has been registered with Copyright Clearance Center.  
For further information, please contact the Copyright Clearance Center,  
Salem, Massachusetts.

Published by:

The Electrochemical Society  
65 South Main Street  
Pennington, New Jersey 08534-2839, USA

Telephone 609.737.1902

Fax 609.737.2743

e-mail: [ecs@electrochem.org](mailto:ecs@electrochem.org)

Web: [www.electrochem.org](http://www.electrochem.org)

ISSN 1938-6737 (online)

ISSN 1938-5862 (print)

ISBN 978-1-56677-716-2 (PDF)

ISBN 978-1-60768-066-6 (Softcover)

Printed in the United States of America.

---

## Table of Contents

*Preface* *iii*

### Chapter 1 New Salts/Solvents/Additives

Novel Electrolyte for Lithium Ion Batteries: Lithium Tetrafluorooxalatophosphate (LiPF<sub>4</sub>C<sub>2</sub>O<sub>4</sub>) 3

*M. Xu, A. Xiao, L. Yang and B. Lucht*

Ion Diffusion and Lithium Jump of Li<sub>2</sub>B<sub>12</sub>F<sub>12</sub> dissolved in Propylene Carbonate (PC) studied by NMR Spectroscopy 13

*K. Hayamizu, M. Hattori, J. Arai and A. Matsuo*

Physical and Electrolytic Properties of Partially Fluorinated Organic Solvents and Its Application to Secondary Lithium Batteries: Partially Fluorinated Dialkoxyethanes \* 23

*Y. Sasaki, G. Shimazaki, N. Nanbu, M. Takehara and M. Ue*

Lithium-Ion Electrolytes Containing Flame-Retardant Additives for Increased Safety Characteristics 33

*K. A. Smith, M. C. Smart, G. Prakash and V. B. Ratnakumar*

### Chapter 2 Ionic Liquid Electrolytes

Mixtures of Ionic Liquid in Combination with Graphite Electrodes: The Role of Electrolyte Additives and Li-salt \* 45

*S. F. Lux, M. Schmuck, B. Rupp, W. Kern, G. B. Appetecchi, S. Passerini, M. Winter and A. Balducci*

Electrochemical and Physicochemical Properties of PYR14-FSI Based Electrolytes with LiFSI 51

*E. E. Paillard, Q. Zhou, W. Henderson, G. B. Appetecchi, M. Montanino and S. Passerini*

Li/LiCoO <sub>2</sub> Cell Performance Using Ionic Liquids Composed of N,N-Diethyl-N-methyl-N-(2-methoxyethyl)ammonium - Effect of Anionic Structure *	59
<i>H. Matsumoto, H. Sakaebe and K. Tatsumi</i>	
Electrochemical Lithium Insertion/Extraction for Carbon Electrodes in FSI-based Ionic Liquids	67
<i>M. Ishikawa, T. Sugimoto, Y. Atsumi, M. Yamagata, M. Kikuta, E. Ishiko and M. Kono</i>	
Properties of BMIBF <sub>4</sub> -LiBF <sub>4</sub> Electrolytes for Lithium Ion Batteries	75
<i>N. Giroud, H. Rouault, E. Chainet and J. Poignet</i>	

### **Chapter 3** **Solid/Polymer Electrolytes**

The Investigation of Electrochemical Properties and Ionic Motion of Functionalized Copolymer Electrolytes Based on Polysiloxane	91
<i>F. Wang, Y. Wang and C. Wan</i>	
Investigation on the Anion Complexation Ability of Organoboron Additives in Lithium-ion Battery Electrolytes - Spectroscopic Approach	105
<i>G. Zukowska, M. Szczechura, M. Marcinek, A. Zubrowska, A. Adamczyk-Woźniak, A. Sporzyński and W. Wieczorek</i>	
Preparation and Performance of Novel Acrylonitrile (AN)-based Copolymer Gel Electrolytes for Lithium Ion Batteries	115
<i>W. Pu, S. Zhang, L. Zhang, X. He, C. Wan and C. Jiang</i>	

### **Chapter 4** **Interface/Kinetics**

Ionic Liquids and their Analogs—Electrochemical Behavior at Electrode/Electrolyte Interface *	125
<i>T. Matsui, M. Deguchi and H. Yoshizawa</i>	
Lithium-ion Kinetics at Interface between Lithium-ion Conductive Electrolyte/DMC-based Electrolyte Interfaces *	135
<i>Y. Yamada, T. Abe and Z. Ogumi</i>	
Surface Analysis of Solid Electrolyte Interphase on Binder-free Graphite Electrodes in Advanced Electrolytes	141
<i>A. Xiao, B. Lucht, L. Yang, S. Kang and D. Abraham</i>	

Charge Transfer and Charge-Discharge Kinetics in Lithium-ion Batteries	163
<i>T. R. Jow, J. L. Allen, B. Deveney and K. Nechev</i>	

## **Chapter 5** **Properties/Performance**

Thermal Behavior of Ionic Liquid Electrolytes in Lithium-ion Cells	173
<i>M. Ue, H. Tokuda, T. Kawai, M. Yanagidate and Y. Otake</i>	

Physicochemical Properties of Non-Aqueous Solvents and Electrolytes for Lithium Battery Applications	183
<i>M. S. Ding and T. R. Jow</i>	

An Organic Electrolyte Mixed with a Quaternary Phosphonium Salt for Lithium Secondary Batteries	215
<i>K. Tsunashima, F. Yonekawa, M. Kikuchi and M. Sugiya</i>	

A New Concept for Lithium Primary Cells using Poly(Carbon Monofluoride) Cathode -The Effect of Quinone Compounds as an Electrolyte Additive	223
<i>D. Noda, M. Takeda, S. Kinoshita and M. Ue</i>	

Author Index	229
--------------	-----

*\* invited paper*