



US006713212B2

(12) **United States Patent**
Aurbach et al.

(10) **Patent No.:** **US 6,713,212 B2**
(45) **Date of Patent:** ***Mar. 30, 2004**

(54) **HIGH-ENERGY, RECHARGEABLE
ELECTROCHEMICAL CELLS**

4,917,871 A * 4/1990 Dahn et al. 423/61
5,491,039 A 2/1996 Shackle
5,849,432 A 12/1998 Angell et al.

(75) Inventors: **Doron Aurbach**, Bnei Brak (IL); **Orit Chasid**, Zur-ig'al (IL); **Yossi Gofer**, Hod Hasharon (IL); **Chaiim Gizbar**, Holon (IL)

FOREIGN PATENT DOCUMENTS

JP 5-343065 12/1993
JP 6-223818 8/1994

(73) Assignee: **Bar-Ilan University**, Ramat Gan (IL)

OTHER PUBLICATIONS

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

Liebenow "A Novel Type Of Magnesium Ion Conducting Polymer Electrolyte" (Electrochimica Acta, Vol 43, Nos. 10-11, pp. 1253-1256. 1998) No month available.

This patent is subject to a terminal disclaimer.

* cited by examiner

Primary Examiner—Stephen Kalafut
Assistant Examiner—R Alejandro

(21) Appl. No.: **09/870,707**

(74) *Attorney, Agent, or Firm*—G. E. Ehrlich (1995) Ltd.

(22) Filed: **Jun. 1, 2001**

(57) **ABSTRACT**

(65) **Prior Publication Data**

A solid, gel type non-aqueous electrolyte for use in an electrochemical cell, the electrolyte including: (a) at least one polymer compound; (b) at least one organic solvent, and (c) at least one electrolytically active salt represented by the formula:

US 2001/0049060 A1 Dec. 6, 2001



Related U.S. Application Data

(63) Continuation-in-part of application No. 09/419,940, filed on Oct. 18, 1999, now Pat. No. 6,316,141.

in which: M' is selected from the group consisting of magnesium, calcium, and aluminum; Z is selected from the group consisting of aluminum, boron, phosphorus, antimony and arsenic; R represents radicals selected from the following groups: alkyl, alkenyl, aryl, phenyl, benzyl, and amido; X is a halogen (I, Br, Cl, F); m=2-3; n=0-5 and q=6 for Z=phosphorus, antimony, and arsenic, and n=0-3 and q=4 for Z=aluminum and boron, wherein the polymer compound, organic solvent, and electrolytically active salt interact to form a non-aqueous electrolyte having a solid, gel type structure. The solid, gel type non-aqueous electrolyte is preferably incorporated into an electrochemical cell further including a metal anode and an intercalation cathode.

(51) **Int. Cl.**⁷ **H01M 6/04**

(52) **U.S. Cl.** **429/188**; 429/199; 429/324; 429/319; 252/62.2

(58) **Field of Search** 429/303, 300, 429/304, 306, 319, 188, 199, 324, 220, 231.5, 231.6; 252/62.2

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,104,450 A 8/1978 Whitney et al.
4,139,681 A * 2/1979 Klemann et al. 429/191
4,511,642 A 4/1985 Higashi et al.
4,894,302 A 1/1990 Hoffman et al.

18 Claims, 2 Drawing Sheets