Proposed Survey Plan

Survey on trend of components for automotive lithium-ion batteries

Trend of preceding automotive lithium-ion battery suppliers in Japan and their outlook on demand for future electric vehicles (EV, PHEV and HEV)

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INDUSTRIAL MARKETING CONSULTANTS CO., LTD.

1. Objectives of Survey

◇ In recent years, automobile manufacturers have announced in the press that they are ready to commence production of hybrid electric vehicles (HEV), electric vehicles (EV), and plug-in hybrid electric vehicles (PHEV), all of which are equipped with large lithium-ion batteries, by 2010, as the development of the large automotive lithium-ion battery has reached the final phase. In Japan, the cumulative number of HEV sales has already exceeded 1 million units during the 10 years since 1988, in which Toyota released the nickel-metal-hydride battery-mounted Prius.

◇ Within such a context, lithium-ion battery-based vehicles have been anticipated to be put into practice since the lithium-ion battery can be downsized with a larger electric capacity than the nickel-metal-hydride battery. The lithium-ion battery, however, has often caused ignition accidents in consumer electric devices such as mobile phones and PC. Therefore, battery manufacturers are focusing on the development and practical application of lithium-ion batteries with better safety in collaboration with automobile and component manufacturers, because usage conditions are more severe in automobiles.

◇ This survey focuses on anode and cathode material, electrolytic solution, and separator, all of which are major components of vehicles equipped with lithium-ion batteries. Following the collection of information by visiting every component or battery manufacturer, this survey intends to reveal the current and future development and commercialization as well as current use of the major components as development currently has come to the final phase. In fact, vehicles equipped with lithium-ion batteries will be released in the near future. This survey will identify the problems and challenges of the major components, and problems related to release in about 2010 and successive commercial production. Moreover, it should be clarified whether commercial production will actually be achieved around 2013 to 2015, which has been reported by mass media.

2. Subjects

Subject		Types	Remarks
Anode material		(1) Ternary (LNMC) (5) Other (2) Ni-based (LNC) (3) Mn-based (LMC) (4) Fe-based (e.g.,LiFePO4)	Progress of additive development
Cathode material		(1) Carbon/graphite (5) Other (2) Oxide (3) Alloy (4) Lithium metal	Progress of additive development
Electrolyte solution	Electrolyte	(1) Lithium hexafluorophosphate (LiPF6) (4) Other (2) Lithium tetrafluoroborate (LiBF4) (3) Lithium perchlorate (LiClO4)	Including new solvents such as ionic liquid and solid electrolyte
	Organic solvent	(1) Ethylene carbonate (EC) (5) Other (2) Propylene carbonate (PC) (3) Diethyl carbonate (DEC) (4) Dimethyl carbonate (DMC)	Potential alternative to existing material
Separator	Wet process	(1) 2 components (2) 3 components (3) Other (e.g. aramid layer + PP, ceramic particle + PP)	
	Dry process	(1) Monolayer (PE, PP) (3) Other (2) Multilayer (PP/PE/PP)	

3. Subjects – (1)

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Material	Suppliers
Anode material	(1) Mitsubishi Chemical (2) JFE Mineral (3) Sumitomo Metal Mining (4) Tanaka Chemical (5) AGC Seimi chemical (6) Nippon Chemical Industrial (7) Nichia (8) Toda Kogyo (9) Mitsui Engineering & Shipbuilding (10) Other (e.g. Mitsui Mining & Smelting, Nippon Mining & Metals)
Cathode material	(1) Hitachi Chemical (2) JFE Chemical (3) Osaka Gas Chemicals (4) Tokai Carbon (5) Nippon Carbon (6) Kureha (7) Showa Denko (8) Hitachi Powdered Metals (9) Mitsui Mining (10) Mitsui Mining & Smelting (11) Hitachi Maxell (12) Fukuda Metal Foil & Powder (13) Mitsubishi Chemical (14) Other
Electrolyte solution	(1) Ube Industries (2) Mitsubishi Chemical (3) Tomiyama Pure ChemicalIndustries (4) Stella Chemifa (5) Dai-ichi Kogyo Seiyaku (6) Central Glass (NipponChemicalIndustrial) (7) Toyo Gosei (8) The Nippon Synthetic Chemical Industry (9) Idemitsu Kosan (10) Other
Separator	(1) Asahi Kasei Chemicals (2) Tonen Chemical (Tonen Chemical Nasu) (3) Sumitomo Chemical (4) Japan Vilene (5) Teijin (6) Mitsubishi Chemical (MitsubishiPlastics) (7) Tayca (8) Toyobo (9) Nihon Matai (10) Matsumura Oil Research (11) Other

3. Subjects – (2)

Other	Miscellaneous manufacture	Other	Miscellaneous manufacture
Automobile manufacturer	(1) Toyota Motor (2) Mitsubishi Motors (3) Nissan Motor (4) Honda Motor (5) Mazda Motor (6) Other	Battery manufacturer	(1) Panasonic EV Energy (2) Automotive Energy Supply (3) Lithium Energy (4) Hitachi Vehicle Energy (5) Sanyo Electric (6) GS Yuasa (7) Enax (8) Toshiba (9) Other
Other	(1) NEDO (2) Battery Association of Japan (3) Other		

4. Survey Items – (1)

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I. Progress of component development

The following topics are investigated for each subject (cathode material, anode material, electrolytic solution, and separator):

1. History of small lithium-ion battery production (progress)
2. Progress of component development for automotive lithium-ion batteries
    (1) Type and profile of components under development (advantages and disadvantages)
    (2) Promising components at this point and reasons
3. Automotive lithium-ion battery component manufacturers
    (1) List of suppliers by component material
    (2) Development and production trend of suppliers
        * Summarizing the development stage and the outline of production equipment
        * Trial models are covered, if available
    (3) Promising suppliers and reasons
4. Estimated price of automotive lithium-ion batteries
    (1) Estimated price of each component material
    (2) Potential reduction of cost (and reasons)
5. Estimated demand for automotive lithium-ion batteries
    (1) Planned and potential adoption by component material
    (2) Estimated demand for each component material in the next 5 and 10 years, and reasons
        * Standard energy consumption per cell of the automotive lithium-ion battery and per vehicle
    (3) Promising component material and reasons
6. References
    i) Major manufacturers' attitude toward and views on large lithium-ion batteries
    ii) Other

4. Survey Items – (2)

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II. Overview of large lithium-ion battery

Relationships among component, battery, and automobile manufacturers

1. Component suppliers vs. battery manufacturers
    (1) Relationships between battery manufacturers and anode material, cathode material, electrolytic solution, or separator suppliers
    (2) Background of the relationships described in (1) and reasons
    (3) Promising pairs due particularly to close ties
2. Battery manufacturers vs. automobile manufactures
    (1) Relationships between manufacturers
    (2) Automobile manufacturers' specific production plans of vehicles equipped with the lithium-ion battery and types of the vehicle
        * Types of automobile (HEV, PHEV, and EV)
    (3) Announcement vs. prototype and commercial production
        * Actual production times may be different from those included in press releases, which often reflect wishful thinking.

4. Survey Items (Viewpoints)

Subjects	Viewpoints of the survey
Anode material	■ Promising anode material candidates for the large lithium-ion battery include ternary, Ni-, Mn-, and Fe-based materials. They are under active development. After investigating the time of full-scale practical application of each material and their potential, the most probable material will be considered. → Notable materials: LiMn2O4, LiNi1/3Mn/3Co1/3O2, LiNi.0.8CO0.2O2, LiFePO4 → What will come following the olivine material (LiFePO4)? (e.g. Possibly Li2MO3) → Other (e.g. Progress of research on composites of oxides and conductive polymers, niobium or vanadium material, organic sulfur material, and potential application to automobiles) ■ Possible and current use of additives ■ What is the appropriate anode material for different eco-friendly automobiles (HEV, PHEV, and EV)? →Performance required for anode material and appropriate material for each eco-friendly automobile ■ Other (e.g. Relationships between anode material and binder, cathode material, or electrolytic solution)
Cathode material	■ Grasping the direction and potential of existing materials (carbon, graphite) and new materials (oxides, alloy, metal lithium) → Carbon or graphite anode materials have safety issues in addition to a performance problem where the limit of electric capacity is reached. What is the most probable new material for the large lithium-ion battery under such restrictions? When is the full-scale practical application of the new materials? In addition, what are the requirements for breakthrough? → Notable materials (1): carbon/graphite: hard carbon, natural graphite → Notable materials (2): oxide: lithium titanate → Notable materials (3): alloy: silicon (single types, composites) ■ Possible and current use of additives ■ What is the appropriate cathode material for different eco-friendly automobiles (HEV, PHEV, and EV)? →Performance required for cathode material and appropriate material for each eco-friendly automobile ■ Other (e.g. Relationships between cathode material and binder, anode material, or electrolytic solution)

4. Survey Items (Viewpoints)

Subjects	Viewpoints of the survey
Electrolyte solution	■ Grasping the direction and potential of organic electrolyte solution ■ Flame-resistant or fireproofing finish (use of additives) → Notable materials: CHB (cyclohexylbenzine), phosphazene, other possible additives ■ Trend of organic solvent usage → (1) Cyclic ester: Transition to PC from currently main EC or other possibilities (and reasons) → (2) Chain ester: DMC will be continuously used as the main material or other possibilities (and reasons) * Will there be any alternative to existing material or not? Also, reasons for answers. ■ Trend of electrolyte solution usage → Lithium hexafluorophosphate will be continuously used as the main material or other possibilities (and reasons) ■ Potential combinations of organic solvent and electrolyte solution ■ Possibility and potential of practical application of ion solution and solid electrolyte ■ Other (e.g. Relationships with anode and cathode materials)
Separator	■ The current development of a separator for the large lithium-ion battery is based on that for the small lithium-ion battery. Higher performance is required, however, for the large automotive batteries since they are used under more severe conditions. This survey will grasp the direction and potential of separator development including existing and new (higher performance) types. → What is the background or context that requires higher performance separators? What are significantly desirable performances (e.g. mechanical strength, heat resistance)? → Notable materials (1): Co-extrusion separator (Tonen Chemical) → Notable materials (2): Inorganic-blended separator (Asahi Kasei Chemicals) → Notable materials (3): Other (Separator including an aramid layer, separator containing ceramic microparticles) ■ The direction and potential of each of manufacturing process (wet or dry) ■ What is the appropriate separator for different eco-friendly automobiles (HEV, PHEV, and EV)? → Performance required for separator and appropriate material for each eco-friendly automobile

5. Date of Completion and Target Price

Scheduled completion date	**Within 70 days after conclusion of the survey purchase agreement**
Price	**JPY 600,000**

*** Style of the report: 4-item survey**
(Total number of pages: approximately 160)

Survey on trend of components for automotive lithium-ion batteries			
Name of company		Telephone	
Name of person in charge		Department/ section	

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6. Introduction of Company

Founded in 1967 as a market research company, Industrial Marketing Consultants Co., Ltd. has significantly contributed to the industry and accumulated affluent knowledge and experiences for about 40 years, now covering a broader range of areas from industrial to consumer goods and services.

The information in our reports is collected through direct visit to or telephone interview with manufacturers, distributors, consumers, and other relevant parties, according to our motto "Providing useful information gathered via direct contact with interested parties."

- Corporate name: Industrial Marketing Consultant Co., Ltd. [Please visit http//www.kohken-net.co.jp for details]
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- Capital: JPY 15,000,000
- Established: July 1967
- Number of employees: 120
- Business: Market research related to all kinds of industry, including materials & products, environment, engineering, recycling, resources & energy, digital imaging, industrial technology, mobility, physical distribution, IT, intelligent home appliances, security, new businesses, equipment items, health & welfare, equipment & services, and more
- Number of clients: 2,000
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