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COMPARATIVE ASSESSMENT OF COMMERCIALY AVAILABLE MATERIALS FOR USE AS SEPARATORS IN Ni-Cd BATTERIES

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Measurements of various properties, considered to be relevant for assessing the performance of a separator material have been undertaken for different commercially available materials having potentials for use as battery separators. These studies have been carried out in order to assess the relative merits of these commercially available materials for their use as separator materials for Ni-Cd batteries.

Key words: Ni-Cd batteries, Separator evaluation, Alkaline battery separator.

Introduction

Different separator materials have been used in the manufacturing of Ni-Cd batteries [1]. The required characteristics of the separator materials include such properties as electrical resistivity, porosity, electrolytic absorption, retention, and alkali resistance. While the nylon or polypropylene in single or double layer has been reported to give better cell performance, yet there are available a number of commercially available materials that have potentials for use as separators. These materials include cellophane sheets, moulded rubber, non-woven-nylon synthetic fabrics, chemically treated membranes of synthetic resin in single or multilayers.

This study has therefore, been undertaken to assess the relative merit of these commercially available materials for use as separator materials. In literature [1,2] a number of properties such as electrolytic absorption, retention, electrical resistivity, wicking time, wet out time, air permeability and porosity have been identified for the performance assessment of separator materials.

Experimental

The materials selected for this study include those which are commercially available as separators for Ni-Cd batteries under trade names and also the materials which are presently not being used as separator but have potentials for use as battery separator. The identification of each specimen is given in Table 1. The materials have been designated as A to L and classified according to their composition and manufacturing technique; the trade names and the manufacturers names have been omitted for commercial products that are marketed as battery separators under trade names. However, such details may be made available on request.

The measuring techniques for the different parameter, namely apparent density, porosity, thickness, electrolytic absorption and retention, wet-out time, wicking time, air permeability and sp. resistivity, as adopted for these studies are essentially the standard techniques reported in literature [2];

however, some modifications/variations had to be made for some measurement according to local environments and in some cases to circumvent the difficulty due to the non-availability of specific equipment. These modifications/adoptions have been made especially for two measurements, namely air-permeability, and electrical resistivity tests. Some instrument details of the measuring set-up for these measurements are given here; for other parameters, namely apparent density, porosity, thickness, electrolytic absorption, electrolytic retention, wetout time and wicking time the recommended methods as given by H.A. Baker *et al.* [2] have been faithfully followed.

Air permeability. This procedure consists of measuring the time required for 300 ml of air to permeate a 0.645 sq. cm area of specimen under uniform pressure equivalent to 3.1 cm head of water. In reported literature [2] a Gurley densometer, model 4110, with a 141 gms inner cylinder is used for the test. As Gurley densometer was not available, a simple set-up (Fig.1) consisting of an aspirator, a water monometer and

TABLE 1.

Sample identification	Compositional identification	Weight/meter ² (gms)
A	Non-woven nylon	68
B	Non-woven polypropylene	34
C	PE grafted cross-linked film	31
D	PP grafted film I	37
E	PP grafted film II	41
F	Nylon woven cloth (imported)	98
G	Nylon woven cloth (soft), locally made	67
H	Nylon woven cloth (hard), locally made	58
I	Nylon spun bounded	68
J	PP/PE, 67%/33% spun bounded	155
K	Alkali resistance filter paper cellulose based	84
L	Cellulose plus synthetic fibre base paper	100

PE: Polyethylene; PP: polypropylene.

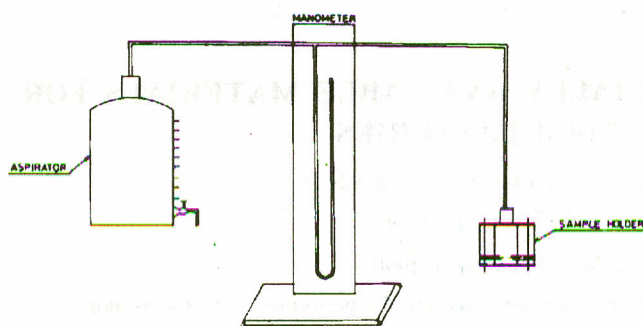


Fig. 1. Set up for measurements of air permeability.

holder for fixing the specimen was made to serve the purpose of Gurley densometer. The pressure is adjusted by the flow of water and the volume of air passing through the separator is measured by the displacement of water in the aspirator.

Electrical resistance. The literature [2] suggests the use of universal bridge operated in the internal mode (1592 Hz) for electrical resistivity measurements, but for this work a Marconi Universal bridge 2700, operated at 1KC internal mode, was used with slight modification in the design of the cell. A permanently fixed cell has been developed having anode and cathode of the same surface area as that of sample. A large number of sample pieces can be accommodated between the electrodes, this giving a comparatively better average value of the measured parameter.

For taking the measurements specimens were cut by a die and were placed in 31% KOH sol. for 24 hr, prior to test. The cell was filled up with the electrolyte upto a given level, and first blank reading was taken by a Marconi Universal bridge

2700; after taking the blank reading, the soaked specimens were introduced into the empty cell and then the cell was topped up to the required level with the electrolyte. After allowing 3-5 mins; the electrolyte was drained off by inverting the cell and allowing the last drop of the free electrolyte to drop out. Then the resistivity of the specimen was measured. Subtracting the blank reading from this value the resistance of the separator was obtained and then the sp. resistivity of the specimen was calculated by using the formula:

$$\rho = \frac{R_s}{T} \times A$$

where ρ is the sp. resistivity of the specimen; T is the thickness in cm., A is the area in cm^2 and R_s is the resistance of specimen.

Results and Discussions

Obviously there is no one parameter test for evaluating a separator material; they have to be evaluated for a number of physical properties and the best material for a particular requirement may have to be based on a compromise between different properties. Some fundamental properties, such as low sp. resistance, low resistance to air permeation, high electrolytic absorption, good electrolytic retention have been recommended for assessing the suitability of any material for its use as battery, separator, the wicking characteristics and wetout time are significant parameters at the filling stage of the batteries. Basically there are two systems of Ni-Cd batteries, one is vent type and the other is sealed type. The relative importance of the different properties varies with the type of

TABLE 2.

Sample	Apparant density gm / cm^3 *	Porosity % *	Thickness cm *	Electrolytic absorption % *	Electrolytic retention % *	Wicking time time to reach 6cm. *(min)	wet out time *(min)	Airpermeability time 1300 ml air to pass ** (Sec)	Sp. resistivity ohm.cm. ***
A	0.16	50	0.4	400	95	314	3.5 cir/hr	3.9	2.7
B	0.39	39	0.09	129	76	25	2	12.0	18.0
C	0.73	40	0.04	70	80	-	-	-	25.4
D	0.52	26	0.07	77	64	-	-	-	15.0
E	0.51	36	0.08	84	64	-	-	-	14.0
F	0.29	31	0.34	143	92	20	8	3.6	4.2
G	0.54	27	0.13	64	78	70	18	22.6	2.5
H	0.41	33	0.13	105	64	40	10	6.9	2.3
I	0.37	40	0.17	140	86	45	46	5.3	3.4
J	0.23	51	0.67	306	56	80	4	4.0	2.0
K	0.69	*182	0.12	335	93	210	24 Sec.	7.0 min.	6.0
L	0.48	*118	0.21	312	92	240	25 Sec.	8.5 min.	3.0

* Average of 5 specimen., ** Average of 10 specimen., *** Average of 100 specimen., * These values are deceptive, this is because of the fact that both samples are cellulose-based, and as the result of the swelling and degradation of these samples in electrolyte (the measurement procedure requires the soaking of samples in electrolyte for 24 hr prior to take reading) caused greater electrolyte absorption due to increase in gross dimensions, these values were bound to be on the higher side.

battery e.g. electrolytic absorption and retention are more important requirements for a sealed system.

The measured values for the different parameter of the different samples are given in Table 2. Sample A is a non-woven nylon material; it is a commercial material. Its electrolytic absorption and retention properties are excellent, which is indicative of its suitability for use in sealed cell. All other characteristics are reasonably good to make it the most preferable choice for both vent and sealed type batteries.

Sample B is a non-woven polypropylene based materials it is also a commercial material. Although its electrolytic retention and absorption are not as good as that of sample A, yet the other characteristics make it suitable for use as battery separator. In sealed system it may perhaps be used in combination with another material having good electrolytic absorption and retention properties.

Sample C, D and E are polyethylene and polypropylene grafted cross-linked films. Air permeability, wet-out time, and wicking time tests on these specimens could not be done because of the nature of these materials. Electrolytic absorption and retention are not good. These may, therefore, be perhaps used in double or triple layers in combination with other materials having good electrolytic retention and absorption properties.

Sample F, G and H are woven nylon cloth materials. In respect of specific resistivity, air permeability and strength against electrolyte, all the three are reasonably suited for use as separators for vent type batteries; however G and H are poor in respect of electrolytic absorption and retention. Sample F

has reasonably good absorption and retention properties as well and may therefore, be suitable for use in sealed cell.

Sample I is a material based on spun-bounded nylon fibres. Most of its characteristics, except electrolytic absorption and wet-out time, indicate its potential as a separator material. It is a commercial material. Its manufacturers also claim that it has been used as battery separator by some battery manufacturer.

Sample J is a blend of polyethylene and polypropylene spun-bonded fibres. It is also a commercial material. All its characteristics, except electrolytic retention, are reasonably good, which makes it suitable for use in vent type cells. However its poor electrolytic retention for sealed cells makes it unsuitable for use as separator material.

Sample K and L are respectively alkali resistant cellulose-based and cellulose plus synthetic fibre based papers respectively. All these characteristics of both the materials are reasonably good, except air-permeability but mechanical strength and prolong strength in electrolyte of both samples are not good.

References

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