Effects of ITE's Activators on Performance of New Lead-acid Batteries for Cars in the Discharge at 90A

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Abstract
The discharge performance of commercial available new lead-acid batteries for cars were studied by addition of ITE's activators at about 90A of discharge current to a depth of 9V. The addition of activators showed that the battery deterioration with charge and discharge cycles was depressed. It is suggested that the addition of activators are recommended for the new batteries in commercial or production process. When the charge is performed without regulation of cut-off voltage, specific gravity of electrolyte and cell voltage are increased with charge-discharge cycles.

Keywords
lead-acid battery, charge-discharge, polymer activator, specific gravity

1. INTRODUCTION
We have reported recycle use of deteriorated lead-acid batteries by organic polymer activators the addition of which improves battery performance and cycle life [Minami et al., 2004; Kozawa et al., 2005]. We have also proposed that the main cause of battery deterioration is responsible to the so-called sulfation on negative electrode. When the deteriorated batteries are slowly charged, 85% of them recovers the capacity to 65-85% of original new batteries. Also, the activator material is effective for negative electrode to prevent the sulfation by adsorption of activator molecules.

If the activators are added to new batteries in production process or commercial, the battery performance will be maintained without deterioration to extend the life. It is, therefore, possible to minimize the waste batteries for our environment, because used leas-acid batteries are mostly disposed by land fill.

The present paper describes the effects of activators on new batteries for the starter purpose of cars in commercial and suggests the possibility of the new batteries with the addition of activator.

2. EXPERIMENTAL
2.1 Batteries and activators used
The new batteries of 40B19 (made in a Japanese company) were purchased in commercial for cars, and subjected to the charge-discharge test. ITE's activators (PN30 and PNH2) were added to the electrolyte at the different concentrations as shown in Table 1. These activators are composed of poly vinyl alcohol as a major constituent and other additives.

Table 1 Battery and activator

Battery number	Activator added	
1	None	
2	None	
3	PN30	0.25 g/cell
4	PN30	0.50 g/cell
5	PH2	0.25 g/cell
6	PH2	0.50 g/cell

2.2 Test of battery performance
The battery was charged by SL-3 battery charger (Daiji Kogyo) for 20h. The initial current was 1-2A, and the current decreased to 0.2-0.3A after 20h. hen the battery was discharged to a depth of 9V by constant resistance (120mΩ, correspond to discharge at about 90A) immersed in water [Tachibana et al., 2003]. This charge-discharge process was made repeatedly. The discharge current was measured to calculate the discharge capacity by cramp-type digital multi meter. The specific gravity of electrolyte was also measured after charge and discharge by a conventional float type meter.

3. RESULTS AND DISCUSSION

3.1 Discharge capacity and cycle performance

Figure 1 shows the change in discharge capacity to 30 cycles. This result suggests that the two activators depress the battery deterioration with charge-discharge cycles. The higher concentration of activator is effective for maintaining initial discharge capacity. The effect of activator concentration agrees with our results on the oxidative consumption of organic polymer activators [Nakagawa et al., 2006]. Though the battery (6) with 0.5g/cell of PN30 is more effective for the depression of battery deterioration, there is no big difference between the batteries (3) and (4) with different concentrations of PNH2.

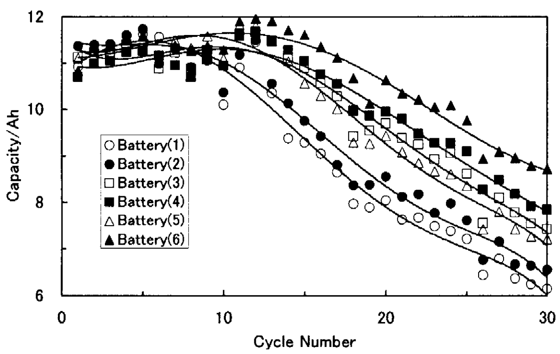
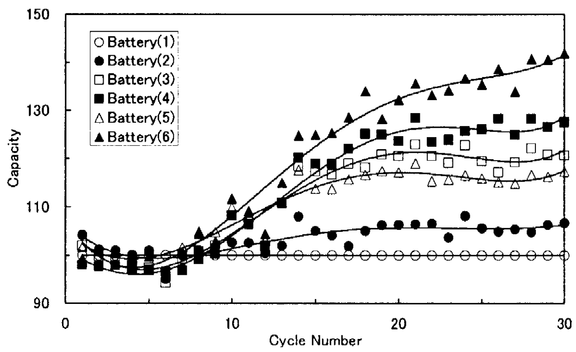


Fig. 1 Change in capacity discharged at 90A to 9V with cycles for the batteries with and without of activators

It is understandable to show the change in the discharge capacity with cycles as Figure 2. The discharge capacity of battery (1) is regarded as 100 in every cycles, and the relative capacity at each cycle is plotted.

The initial discharge capacity is approximately same in every battery. After 10 cycles the battery without activator resulted in the decrease in the capacity to about 50% of initial capacity. On the other hand, the addition of activators resulted in the decrease of deterioration rate, and 75-85% of initial capacity was maintained in



The capacity of Battery (1) ia regarded as 100.

Fig. 2 Change in discharge capacity with cycles

the batteries (4) and (6) after 30 cycles. The result in cycle performance at high rate (90A) discharge tests are similar to that in low rate (below 10A) [Kozawa et al., 2005]. Since the discharge at 90A is completed within 10 min, the high rate discharge test may be recommended to evaluate the battery performance.

3.2 Specific gravity of electrolyte

Figures 3 and Figure 4 show the change in specific gravity of electrolyte with cycle numbers after the charge and discharge. The values of specific gravity were 1.29-1.30 before charge-discharge cycle tests. These values after charge were gradually increased with the cycle numbers, and were about 1.35 after 30th cycle as shown in Figure 4.

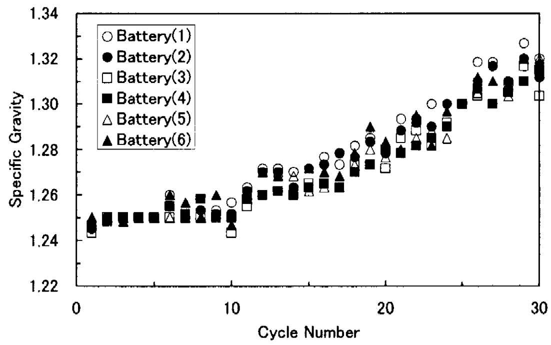


Fig. 3 Change in specific gravity of electrolyte after discharge

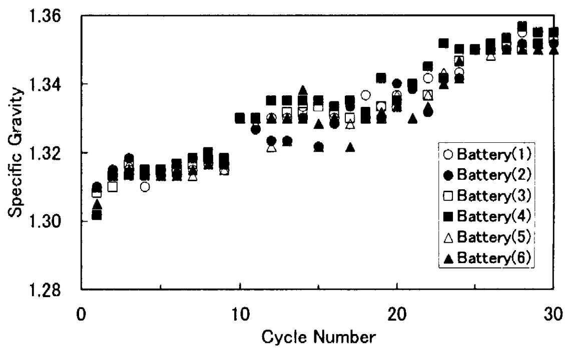


Fig. 4 Change in specific gravity of electrolyte after charge

The values after discharge were also increased with cycle numbers, and about 1.31 at 30th cycle as shown in Figure 4. The batteries without activator give higher values in the specific gravity than that with activator, because of lower discharge capacity. On the other hand, there were clear differences between the batteries with and without activators in the charge process.

Ikeda et al. have reported the increase in the specific gravity of electrolyte with charge-discharge cycles [Ikeda et al., 2005], and discussed based on the sulfation, which is taken into account in the present results. Further studies are, however, needed for the behaviors of specific gravity with charge-discharge cycles.

3.3 Cell voltage and battery performance

Figure 5 shows the closed circuit and open circuit voltages just before and after the end of charge, respectively. The upper cut-off voltage was not regulated in the charger used in this experiment, and hence the charging time was kept constant at 20h. The initial charging current was 1-2A, and 0.25-0.35A at 30th cycle.

The cell voltage at the end of charging process was gradually increased with cycle numbers. Every batteries gave the charge voltage over 16V after several cycles. This increase in voltage is greater in the battery without activator. The open circuit voltage after charge for 20h was also increased with cycle numbers. There are, however, no differences in the presence and absence of activator. The increase in voltage with cycle numbers may be correlated to the increase in specific gravity of electrolyte. In deteriorated batteries impurities such as metal ions from grid material decreases hydrogen over potential. However, no special consideration for impurities should be paid on the charge-discharge performance, because new batteries are used in this experiment. Accordingly, the difference in charge voltage in Figure 5 may be attributed to the effect of activator. When the sulfation is inhibited by activator, active material becomes fine particles to decrease apparent current density and cell voltage.

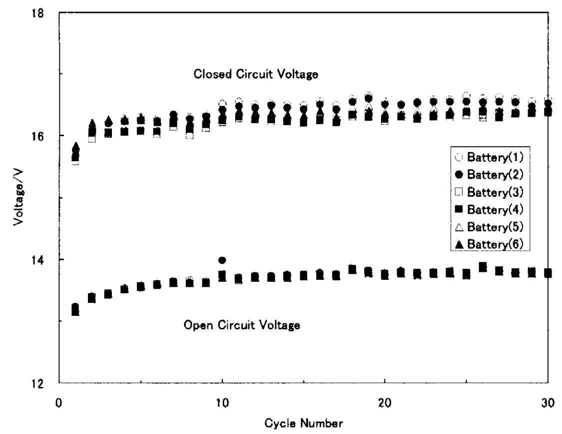


Fig. 5 Closed circuit voltage just before the end of charge process and open circuit voltage after the charge

Figure 6 shows the change in open circuit voltage with cycle numbers after discharge at 90A. There was slight difference of voltage in initial several cycles, and the batteries without activator resulted in the higher values than that with activator. In the battery without activator

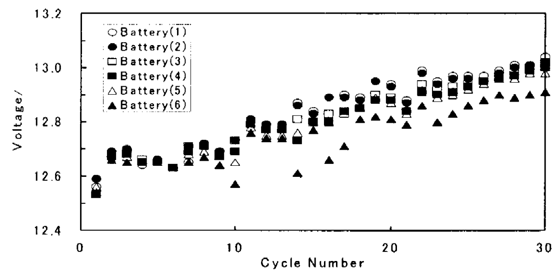


Fig. 6 Open circuit voltage after discharge (before charge)

unreacted active material remains on electrode plates with the progress of charge-discharge cycle. It is considered that he open circuit voltage after discharge becomes higher in the battery without activator.

4. CONCLUSION

The discharge performance of commercial available new lead-acid batteries for cars were tested by addition of ITE's activators at about 90A to a discharge depth of 9V. The activators added to new batteries were effective for the deterioration with charge-discharge cycles. It is suggested that the activators may be added to the new batteries in commercial or production process. The change in specific gravity of electrolyte and cell voltage with charge-discharge cycles was discussed on the basis of function of activator.

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