Patient and dispenser surveys show that there is a demand for a rechargeable solution in hearing instrument technology. The major requirements for a rechargeable solution are long-lasting batteries, usage also with standard hearing aid batteries and easy and effortless recharging. Thanks to the recent introduction of nickel metal hydride (NiMH) technology it now is possible to fulfill these requirements. NiMH batteries are eco-friendly, do not have a “memory effect” and can be recharged in a few hours over night. Under realistic conditions, a 13 size battery is required to guarantee at least one full day of operation. The Siemens CENTRA Active charger provides optimum ease of use as two hearing instruments can be recharged at the same time. The charger recognizes errors like dysfunctional rechargeable batteries, non-rechargeable batteries and wrong polarity. In addition, the instruments are automatically switched off when placed in the charger.
Introduction

In the typical household today, it is common to find a variety of battery operated devices. We all appreciate the convenience and flexibility of a cordless and portable power source. Additionally, there also appears to be a growth in the use of batteries that are rechargeable. This is easily observed in devices such as power tools, cellular phones, digital cameras, laptop computers, mp3 players and other commonly used electronic devices. Rechargeable batteries have even entered the automobile industry. It is reasonable to expect a continuing growth in the use of rechargeable batteries for other applications. With this growing popularity of rechargeable batteries, an obvious and logical application for this technology is in hearing instruments.

It is known that hearing aid batteries are an area where hearing instrument wearers are seeking improvement. Reports indicate that factors such as costs associated with batteries, ease of use and battery life are long-standing concerns for the hearing instrument wearer (Kochkin 2002). A rechargeable battery can help address these concerns. It is important, however, to assure that rechargeable battery technology is of the performance level which addresses these issues and expectations of hearing instrument wearers. An understanding of these requirements is necessary for the successful introduction of rechargeable battery technology into the hearing instrument industry.

Requirements for rechargeable batteries

To investigate these battery requirements in detail, a multi-national focus group study was conducted with audiologists, experienced hearing instrument wearers and future hearing instrument wearers (Wessner, Schindhelm and Heyder 2005). This focus group sought to answer two primary questions: What are the requirements for a rechargeable hearing instrument, and secondly, are rechargeable batteries accepted by both hearing care professionals and hearing instrument wearers?

The study was conducted by independent market research institutes in the USA, France and Germany. The institutes, using a group discussion format, met with forty-eight experienced hearing instrument wearers, forty-eight future hearing instrument wearers and thirty-two hearing care professionals in sixteen group sessions.

The results of these focus group sessions revealed several advantages concerning the rechargeable battery concept. Because there is no need to replace the battery, the hearing instrument wearer would have less handling difficulties with a rechargeable hearing instrument. There also is an economic advantage to rechargeable instruments, due to the reduced need to purchase replacement batteries. For the professionals, there is less involvement in ordering and stocking batteries; for the wearers, there is less involvement with having to depend on a source of batteries. A rechargeable battery also is more environmentally friendly as there is a great reduction in the disposal of exhausted batteries. There is the additional benefit that we discussed earlier: today’s high-tech products use rechargeable batteries; hearing instrument technology now falls into this category.

There also were a few potential disadvantages identified by the research. An obvious concern was battery life and recharging time, as these factors will affect daily hearing instrument use. Another concern identified was related to alternate power supplies and options when the hearing aid wearer forgets or is unable to recharge a battery. These advantages and disadvantages were discussed and weighed in the focus groups to identify preferences and requirements for a rechargeable option, which all groups preferred. Of importance, the wearer groups also reported that they would pay more for a hearing instrument with a rechargeable battery. The hearing care professionals groups were in agreement, in that they believed that hearing instrument wearers would be in favor of the rechargeable solution.
Long lasting battery

Memory effect

As mentioned, it is critical that the rechargeable battery must be long lasting. Two main options for battery technology were the nickel-cadmium (NiCd) cell and a nickel-metal hydride (NiMH) cell. The NiCd cell was determined to not be as environmentally friendly, and also had a memory effect which could potentially decrease daily longevity of the battery. Memory effect refers to the fact that with some rechargeable systems, performance time is based on “memory” of previous time durations prior to being recharged. With batteries that have a memory effect, over time, a battery that was typically recharged while still at half capacity may lose capacity and not last as long as an identical battery that was consistently exhausted before being recharged.

The NiMH battery was determined to be a better option for the rechargeable hearing instrument. NiMH technology was developed in the late 1980’s by Stanford R. Ovshinsky and was made commercially available in the 1990’s (Fetcenko et al. 1992). NiMH provides approximately double the power per package as compared to NiCd. Additionally, NiMH batteries do not contain any dangerous heavy metals like mercury, lead or cadmium and are therefore more environmentally friendly.

<table>
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<tr>
<th>Rechargeable, NiMH</th>
<th>13 NiMH</th>
<th>312 NiMH</th>
<th>675 NiMH</th>
<th>10 NiMH</th>
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Battery size and capacity

Along with choosing the appropriate battery technology, battery size must be considered in designing the optimum rechargeable solution. The 675 sized cell had been used in prior rechargeable options, however, current cosmetic demands dictate that a smaller cell size is required. Advancements with NiMH battery technology provide improved power levels in smaller sizes of 10, 312 and 13 cells that were not previously available. The primary goal with a rechargeable battery capacity is to achieve, at minimum, a full day’s use. The commonly used zinc air batteries of course have a higher capacity than rechargeable batteries, as can be seen in Table 1. This comparison, however, is not appropriate for the rechargeable battery, which needs to power a hearing instrument for a full day and then charge overnight.

As mentioned, in choosing the appropriate size for the rechargeable battery, the minimal standard is that the battery needs to operate for at least one full day. However, as this must be guaranteed for all hearing instrument wearers, in this case one full day could mean operation up to 15 hours! Figure 1 shows operating time in hours for three sizes of batteries according to current measurement standards (linear settings, adaptive parameters off). One can see from the displayed usage hours that a size 10 battery does not have the capacity to operate the hearing instrument for a full day and is therefore not a reasonable option for selecting an appropriate battery size.

When comparing the size 13 and size 312 batteries more closely, it is important to consider the effects on the battery when other aspects of digital processing, such as digital noise reduction, are activated. One can expect a higher demand on the battery due to the increased processing. Therefore, the hours indicated in Figure 1 must be modified to take into account these extra demands. Figure 2 provides a more realistic expectation of operation time from the battery with full functionality of the features of a typical digital hearing instrument. From this chart, it can be seen that a 312 size battery will not provide a long enough operating time for a full day. It is therefore concluded that the practical battery size to achieve cosmetic acceptance and appropriate use time is the 13 size NiMH battery.

Discharge behavior

Another factor to consider with a battery cell is the discharge behavior. Discharge behavior refers to the rate and transition from full battery capacity to the cutoff voltage where it ceases to supply power. The discharge with the NiMH rechargeable battery is very smooth and consistent – very similar to the zinc air battery.

"The minimum operation time for a rechargeable hearing system is 15 hours."
As shown in Figure 3, NiMH cells work at temperatures from -20° to +40° Celsius. However, at very low temperatures, battery lifetime may decrease to 25% of the nominal value at room temperature. For comparison, zinc air batteries operate from -10° to +40° Celsius, and also are less efficient at very low temperatures than at room temperature. As a rule of thumb, NiMH batteries show a similar behavior as zinc air cells – apart from being rechargeable.

Corrosion resistant battery coating

Another aspect of the rechargeable battery is protection against corrosion. Traditional zinc air batteries are expected to last for approximately one week. With this short lifespan, there is little risk for corrosion. However, a rechargeable battery can be expected to last well over one year. This duration puts the rechargeable battery at a much higher risk for corrosion. Siemens applies a clear, polymer film to the rechargeable batteries to inhibit corrosion. The coating is non-tacky and non-conductive. It contains corrosion inhibitors to help protect the battery. Additionally, this coating contains no chlorofluorocarbons (CFCs) or toxic materials and therefore is environmentally safe. In conjunction with the moisture resistant nature of CENTRA Active, the hearing instrument wearer can feel confident in the longevity of the battery performance.

“Rechargeable batteries need to be environmentally safe and corrosion resistant.”
Easy and effortless recharging

With the selection of the rechargeable size 13 NiMH battery, the next important requirement to address is that of recharging. As indicated by the market research discussion groups, recharging needs to be an easy and effortless process. Factors such as use of monaural versus binaural hearing instruments, dexterity concerns and efficient charging times contribute to determining what is “comfortable and acceptable” for a given hearing instrument wearer.

CENTRA Active charger

The rechargeable system designed by Siemens for CENTRA Active incorporates many advantages for the hearing instrument wearer in an intelligent and efficient package. Charging is performed in a compact charger unit that, with the addition of a small silica gel pillow, can also dry the hearing instruments while the batteries are charging. The unit is capable of charging two instruments simultaneously. The instruments are simply placed inside the charging cavities of the charger (Figure 4). The hearing instrument battery doors do not need to be opened, nor do the batteries need to be removed. This is important to support ease of handling. When the instruments are detected, the charger will turn the hearing instruments off automatically to eliminate any risk of feedback while charging. At this point, lights on the charger will indicate that charging is progressing normally or that there is some problem with the charging process (Figure 5).

When normal charging is occurring, the green status light will blink to indicate the charging process. If the charger detects a non-rechargeable battery, a defective battery or batteries with reversed polarity, it will alert the hearing instrument wearer with a steady red charging status light and will not attempt to charge the batteries. As discussed, the battery can last for an entire day and evening before recharging is required. Additionally, as NiMH batteries have no memory effect, there is no negative impact on daily use by recharging a battery that is not fully discharged. The charging process itself with CENTRA Active only takes five hours.

Multi-stage charging

In addition to ease of handling, the optimum rechargeable solution must avoid overcharging, and also maintain a high number of recharge cycles. In contrast to inexpensive pen chargers, therefore, the Siemens charger uses a microprocessor controlled multi-stage procedure which varies the charging current as a function of the on-going charge of the battery. In the beginning, a very high charging current is applied to ensure optimum charging speed. Approaching the complete charge of the battery, the charging current is reduced stepwise to avoid overcharging. Thus, both optimum speed and high safety are achieved. At the conclusion of charging, the charger will indicate that the batteries are fully charged with a steady green charging status light.
With the Siemens charger, a NiMH battery can be recharged about 300 times without significant degradation of capacity (see Figure 6). After more than 300 charging cycles the charging capacity decreases gradually and after about 1000 cycles typically approaches the capacity of a 312 NiMH – a capacity which often is not sufficient for one full day of operation. That means that the Siemens rechargeable-battery system (i.e. Siemens charger in combination with Siemens battery) allows one single battery to be used between 500 and 1000 times. Figure 6 also shows that with other charging procedures, the battery lifetime is likely to be less than 500 recharge cycles.

Taking into account wearer requirements, as well as understanding that at times there may not be an opportunity to recharge a battery, CENTRA Active also operates using standard 13 size batteries. The rechargeable batteries easily can be removed from the battery door and be replaced with the standard battery when there is no opportunity to recharge.

Summary

With current trends in technology and modern designs in hearing instruments, the time has finally come for a rechargeable hearing system that meets the needs of hearing instrument wearers. Research indicates that a functional and practical rechargeable system must have long-lasting batteries that can be easily and comfortably recharged, thus providing the hearing instrument wearer a secure and reliable hearing system. With CENTRA Active by Siemens, these demands for customer satisfaction are met and even surpassed with extra convenience and flexibility.
References

