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Low-Cost Magnetic Stirrer from Recycled Computer Parts with Optional Hot Plate

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S *Supporting Information*

ABSTRACT: Magnetic stirrers and hot plates are key components of science laboratories. However, these are not readily available in many developing countries due to their high cost. This article describes the design of a low-cost magnetic stirrer with hot plate from recycled materials. Some of the materials used are neodymium magnets and CPU fans from discarded computers and recycled electrical components from old circuit boards. This prototype was compared with a commercial magnetic stirrer with hot plate. It was noted that high temperatures were reached at similar rates, and the stirring speed was also comparable between the two. With this prototype, which costs 80% less than commercials ones, magnetic stirrers with hot plate can be readily available to enhance teaching and learning in science laboratories that need them most.

KEYWORDS: *High School/Introductory Chemistry, Public Understanding/Outreach, Hands-On Learning/Manipulatives, First-Year Undergraduate/General, Laboratory Instruction, Laboratory Equipment/Apparatus*

Several research studies have shown that science laboratories provide effective venues for students to observe and understand the world. Meaningful learning is enhanced even further when students have the opportunity to use equipment and materials during their investigations.[1] One piece of equipment that is widely used in science laboratories is the magnetic stirrer. It is made with a magnet that rotates at adjustable speeds, thus inducing the spinning of a magnetic stirrer bar in a reaction vessel. This rotation allows efficient mixing and stirring of any liquid contained within through the strong fluid motion generated by the bar.[2] This equipment ensures continuous stirring within a reaction vessel over periods of time; with a hot plate, it can allow a wide variety of synthetic reactions to occur.

Despite the large role they play in research and education processes, it has been reported that this expensive equipment is not readily available in public high schools in developing countries. In the Philippines, for instance, it was reported in 2010 that there are no magnetic stirrers among 4,000 high school science laboratories in more than 5,000 public high schools nationwide.[3] In the same year, a research in Tanzania reported that around 700 science laboratories require magnetic stirrers.[4] In Latin America and the Caribbean, around 88% of 300 schools surveyed in each country do not even have a science lab.[5] Ideally, each school should have a laboratory, and each one would be equipped with at least one magnetic stirrer. However, one magnetic stirrer that can accommodate 1-L volumes costs around US$160; one with a heating function costs around US$500.[6] At this cost, it would be prohibitively expensive for the government to solely provide these laboratories with the equipment needed for an effective learning experience.

The major motivation in the development of a low-cost magnetic stirrer with hot plate is to provide an inexpensive, yet just as effective, alternative to commercially available units. There are other reports in literature on the assembly of magnetic stirrers,[7−15] hot plates,[16,17] and magnetic stirrers with hot plates.[18−21] Our work adds to this body of knowledge by describing a way of building both heating and nonheating magnetic stirrers from recycled electronic wastes such as computers. This addresses the United Nations Environment Programme report that states that every year, 20 to 50 million tons of electronic wastes are generated worldwide, which includes at least 500 million obsolete computers in the U.S.A. between 1997 and 2007.[22] By recycling computer spare parts and other unwanted items, a less expensive and easy to assemble alternative is provided for schools and laboratories that currently lack teaching and learning resources.

■ MATERIALS AND METHODS

In the design and assembly of both nonheated and heated magnetic stirrers, the following generalized assembly sequence was followed.

1. Design and test the controls for fan speed.
2. Design and test the controls for the heating element (where applicable).
3. Check all available parts.

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4. Check for physical layout (i.e., the parts should fit together).
5. Fabricate the parts that are not readily available.
6. Assemble the stirrers using all the needed tools and equipment.
7. Test for performance, stability, and safety.

The details are described in the succeeding sections, as well as in the Supporting Information.

Magnetic Stirrer Design and Fabrication

A neodymium magnet from a recycled hard drive was secured at the center of a used computer fan using a cyanoacrylate adhesive. From one of the fan's wires, a potentiometer was connected to vary its speed; a toggle switch that turned on the power was also added. A power adaptor was used to convert 220 V AC to 12 V DC; this adaptor may be sourced from other electronic items such as cellphone chargers as long as they exhibit the desired specifications. The computer fan was mounted in the plastic box by placing it in a small plastic cup, which was then screwed to the box. To house these components, a box made from hard plastic was used; this was chosen because it prevented any interference with the magnetic attributes of the internal components. Figure 1 shows the main assembly diagram of a magnetic stirrer.

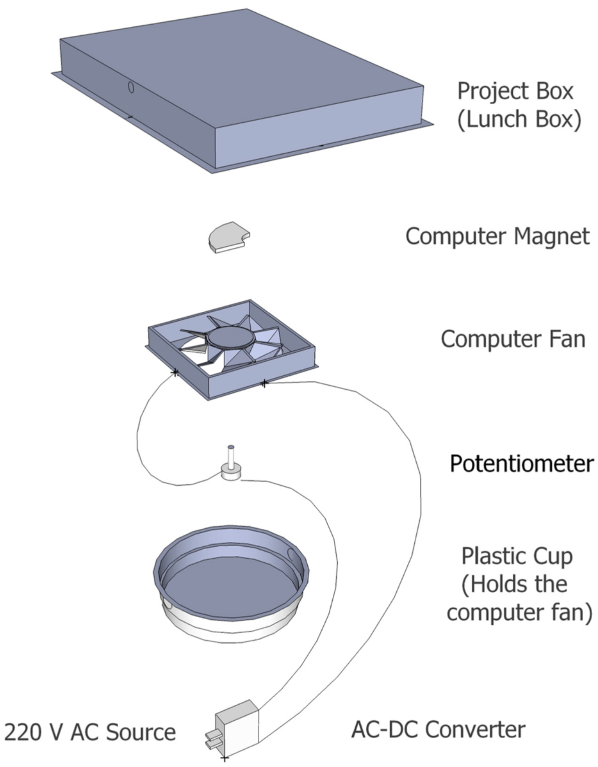

Figure 1. Main assembly diagram of the magnetic stirrer.

To ensure that the blades of the fan would not get jammed, a small gap was placed between the fan and the plastic platform. To prevent vigorous vibration, a general purpose hard rubber tip with a height of approximately half the thickness of the stirrer was used. In addition, a simple 90° angle lock was fabricated from a piece of galvanized iron sheet to hold the bottom plate in place. Figure 2 shows the dimensions of the final product. The specifications of the other components are found in the supplementary documents.

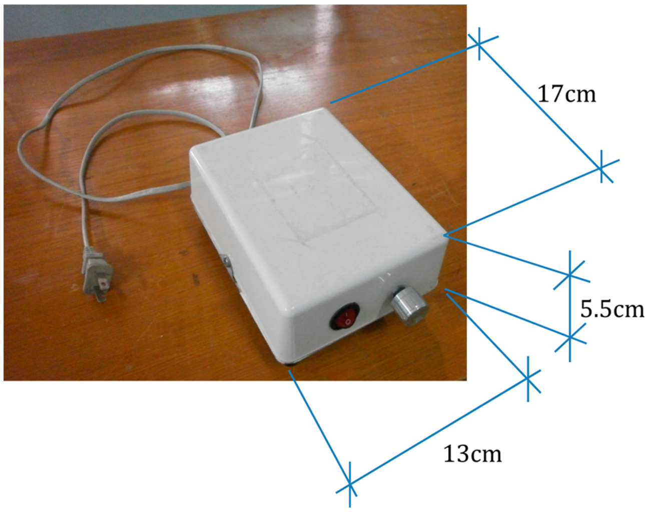

Figure 2. Dimensions of the magnetic stirrer.

Magnetic Stirrer with Hot Plate Design and Fabrication

The parts for the magnetic stirrer are similar for this model. One difference is that two neodymium magnets were used to strengthen the stirring; these were secured using a generic steel epoxy on top of a fan rotor. Another difference is that an electric heat coil (i.e., a heating element) was added to allow mixing liquid substances at higher temperatures. A procured electric stove with a 20 cm diameter loop was modified by replacing the heat pad with a stainless steel plate. Figure 3 shows the main assembly diagram of the magnetic stirrer with hot plate.

Figure 4 shows the diagram of electrical components needed; these are powered by both AC and DC sources. The built-in mechanical thermal switch selector of the procured electric stove regulates the heat coil, and the variable ceramic resistance

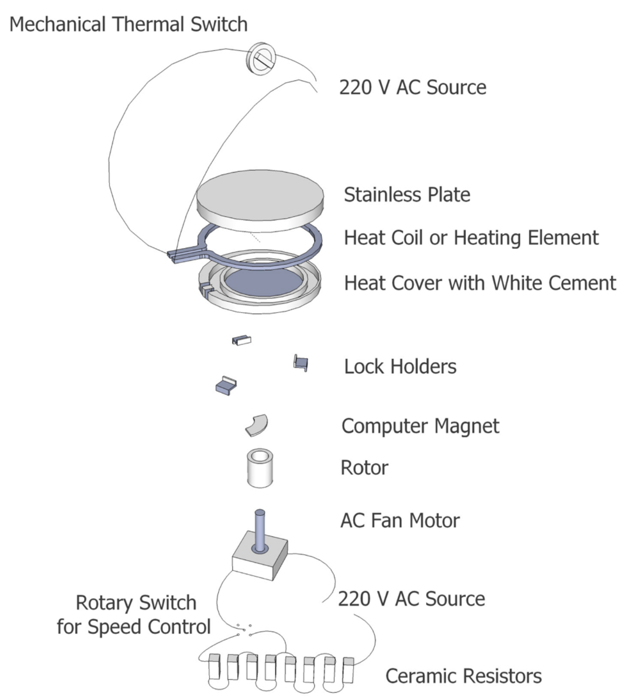

Figure 3. Main assembly diagram of the magnetic stirrer with hot plate.

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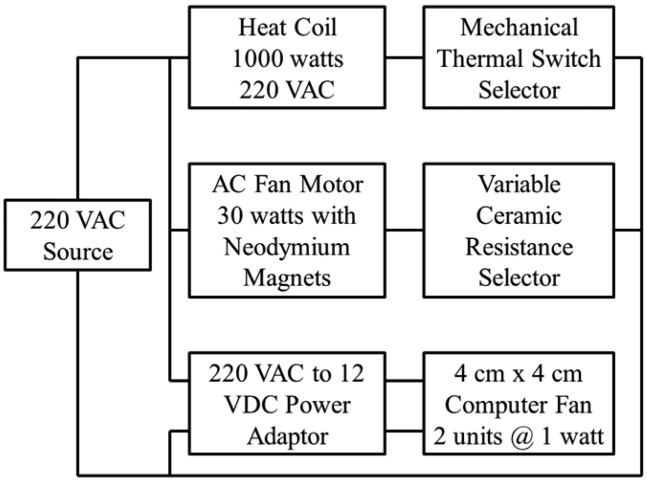

Figure 4. Electrical diagram for the internal components of the magnetic stirrer with hot plate.

selector varies the fan speed (i.e., stirring speed) from slow, medium, and fast options. To dissipate the heat inside, two recycled computer fans were used. The final dimensions of the magnetic stirrer with hot plate are shown in Figure 5.

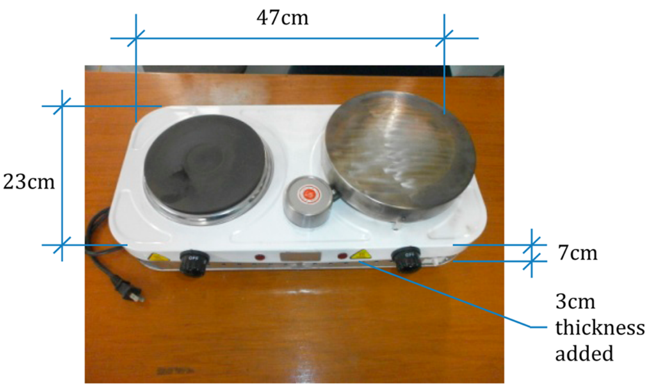

Figure 5. Magnetic stirrer with hot plate and its dimensions.

■ RESULTS AND DISCUSSION

Some modifications were made to the stove and its accessories. Heating coils that heat up to 1000 W at the sides were used; a larger stainless steel heating plate was fabricated to accommodate this new coil and to minimize the transfer of heat to the body of the stove. A cover was fabricated to hold white ordinary Portland cement or tile grout that prevents heat from radiating directly down the stove while protecting the motor from excessive heat. A gap between the stove platform and the stainless cover assembly was maintained to minimize heat transfer. To facilitate ventilation, holes were bored on the sides. Additional design details are provided in the supplemental documents. The total material cost of the magnetic stirrer and that of the hot plate is US$29 and US$130, respectively.

Stress tests were conducted on both models. The magnetic stirrer was tested for 8 h for 5 consecutive days. On the other hand, the magnetic stirrer with hot plate was tested for 4 h for 5 consecutive days; there were no signs of overheating of the electronic circuits. In addition, the magnetic stirrer with hot plate was tested alongside a commercial unit. At room temperature (27 °C), both equipment heated 100 and 500 mL water samples at the same rate (i.e., 15 min to boil at 100 °C using maximum settings).

By adjusting the values of ceramic resistors, the stirring speeds can be varied from a low to a high setting, which ranges from 500 to 1500 rpm. These speeds are comparable with commercial units.

To avoid any burn- or fire-related accidents with this product, it is strongly advised that the standards for splicing and insulating wires and other proper handling and electrical practices are observed. To avoid electrocution, unplug any circuit or assemblies with live electrical power before touching them. Protective gloves and tools should be used when handling sharp and rough objects. In addition, any remaining electronic waste parts must be disposed properly. Finally, it is recommended that proper training, an instructional manual, and signage are prepared for users to minimize risks with using the product.

■ SUMMARY

A low-cost magnetic stirrer with hot plate was developed using recycled parts from discarded computers and other electronic wastes. Its performance was compared to commercially available equipment, and it was found to be just as effective while costing around 80% less. This equipment can be used to address the teaching and learning gap in science laboratories worldwide. By addressing this equipment availability issues, especially in developing countries, the drive toward inclusive progress can be pushed in a more concrete and sustainable way.

■ ASSOCIATED CONTENT

Ⓢ Supporting Information

A parts list and assembly details are available. This material is available via the Internet at http://pubs.acs.org.

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Notes

The authors declare no competing financial interest.

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