DIY High-Voltage Paper Electrophoresis for Cost-Effective Charge Separation

AUTHORS

Elizabeth Henstrom, Craig Thulin

01. Abstract

Modern-day scientific instruments are expensive, limiting access for institutions such as schools without resources to afford analytical tools. To address this issue, we have developed a Do-It-Yourself High-Voltage Paper Electrophoresis apparatus, or DIY HVPE. This approach bridges the costs and materials gap, enabling high-voltage electrophoresis with a set-up that can be assembled and used by high school students. The analysis of flower pigments with this apparatus demonstrates acid/base indicators as well as differential electrophoretic migration due to pH-dependent charge. The apparatus can even be used to run two side-by-side experiments at different pHs. Our results show that the DIY HVPE is effective in separating pigments by charge, helping students to gain hands-on understanding of acid/base chemistry and its relation to molecular ionization.

02. Introduction

Electrophoresis is a method that separates molecules based on their size and charge. A current is run through a buffer, which then runs through a medium where a sample is placed. The pH of the buffer determines the charge, and therefore the direction a molecule will migrate by ionizing different functional groups. This could be toward a cathode, anode, or no net movement.
The method of utilizing paper for electrophoresis is considered to be an outdated method, and was replaced by other methods such as cellulose acetate and gel electrophoresis. However, paper electrophoresis is still an excellent way to view migration of small molecules and even make inferences on the effects of pH on molecular chemical structure. Natural pH indicators such as flower pigments are excellent compounds to indicate the viability and success of a run due to their bright colors. This apparatus aims to investigate the effectiveness of using low-cost materials to explore the migration of flower pigments.

03. Methodology

Powdered dry flower petals were extracted with hot water. After centrifugation of the petal extract, 4-2 µL were spotted on filter paper and dried, repeating in 2 µL increments for sufficient visibility. Household ammonia or 30% vinegar was then added to the buffer reservoirs until the platinum electrodes were submerged. The filter paper was then wetted with buffer. The apparatus was set up with optional cooling bags (fig.3). The run was set at 500 V and allowed to run for at least one hour. Pictures of the run were taken at various time points for pigment migration observation.

04. Results

- In order to produce dark-colored and light-stable results, the water ratio should be about 500 µL per 160 mg powdered petals.
- Cooling is not totally necessary for a clear separation to occur, but does allow the pigment molecules to migrate more slowly with somewhat less diffusion.
- The DIY HVPE can be run side-by-side, allowing for two experiments with different pH buffers (ammonia or vinegar) to be run simultaneously.
- The conductivity of the buffer solution in a given filter paper should match in order to perform side-by-side experiments.
- The apparatus can be run at both low cost and little maintenance.

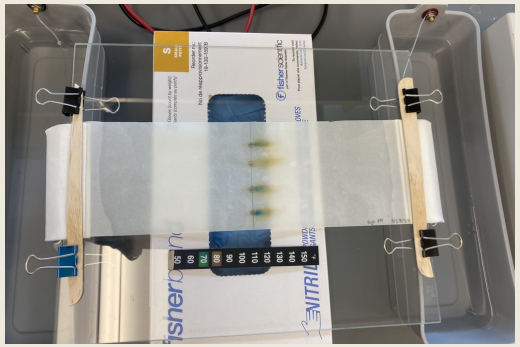

Figure 1. High pH Run

The figure to the left displays a run of the high pH (household ammonia) buffer on the DIY HVPE after only 10 minutes of running a 500 V current. Some streaking is observed. However, three of the four streaks are seen to be streaking to the same amount, suggesting that the results are reasonably consistent.

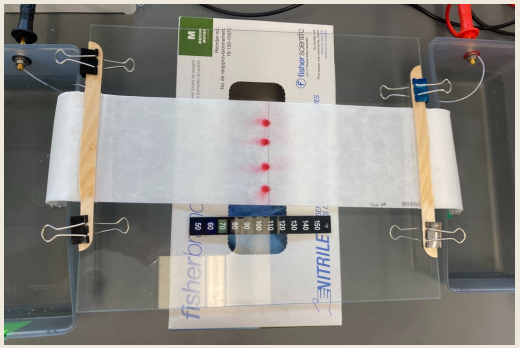

Figure 2. Low pH Run

The figure to the left displays a simultaneous run of the low pH (30% vinegar) buffer on the DIY HVPE after just 10 minutes of running a 500 V current. Again, some streaking is observed, and migration is lower. Note the difference in color for the same flower pigments, due to their serving as pH indicators.

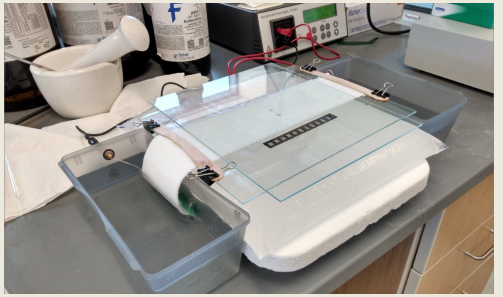

Figure 3. DIY HVPE Apparatus Setup

The image above shows the setup of the DIY HVPE apparatus. Commonplace materials, including household chemicals, glass plates used for framing, Styrofoam, Ziplock bags containing mineral oil placed in the freezer (for temperature regulation), binder clips, and popsicle sticks are integral materials for this cost-effective instrument. The most expensive and specialized parts of the apparatus – the platinum electrodes and high-voltage power supply – can be had from other electrophoresis equipment commonly used in high schools.

05. Conclusions

- The DIY HVPE can be operated by a single person with limited chemical and electrical knowledge.
- A side-by-side run can be performed simultaneously to compare two results at the same time.
- Meaningful pigment molecule migration can be obtained with easily accessible and inexpensive materials.