

Title: Experimental Progress, Theoretical Analysis, and an Unsolved Puzzle in Constructing a Perpetual Motion Machine of the Second Kind Using Osmotic Pressure

Author: Weigang Li

Abstract:

This paper examines a theoretical construct and experimental results for a system purportedly capable of functioning as a perpetual motion machine of the second kind by harnessing osmotic pressure. The setup involves a U-tube divided by two semipermeable membranes into three chambers. The central chamber is filled with a dilute sodium sulfate (or citric acid) solution, while the two side chambers are filled with pure water. An applied electrostatic field creates a difference in the molar concentration of impermeable ions near each membrane. According to the osmotic pressure formula $\Pi = cRT$, this concentration difference induces a corresponding difference in osmotic pressure, theoretically causing water influx (osmosis) at one membrane and outflow (reverse osmosis) at the other, thereby establishing a sustained water level difference. The energy for water molecule transport is derived from ambient thermal energy. By constructing a drainage channel between the side chambers, gravitational work can be continuously extracted as the system perpetually absorbs heat from the environment to re-establish the hydrostatic imbalance. This paper reports experimental progress since the initial 2017 report, including independent verification and an improved experimental design in 2024 that achieved a pure water level difference of 2.8 meters, effectively eliminating concerns about energy input from external sources. These findings challenge the prevailing chemical potential (free energy) theory of osmotic pressure and suggest the feasibility of a nearly 100% efficient heat-to-work conversion mechanism under specific nanoscale conditions. A persistent puzzle regarding the direction of the observed water flow, contrary to theoretical predictions, is presented for resolution.

Keywords: Osmotic Pressure, Second Law of Thermodynamics, Second Kind Perpetual Motion, Semi-permeable Membrane, Reverse Osmosis, Nanofiltration, Energy Conversion, Experimental Puzzle

1. Introduction

The second law of thermodynamics is a cornerstone of classical physics, asserting the impossibility of a perpetual motion machine that converts thermal energy entirely into work without other changes. This paper presents experimental observations and a theoretical framework that appear to challenge this law within a specific microscopic context. We investigate a system where an electrostatic field manipulates ion concentrations near

semipermeable membranes, potentially rectifying Brownian motion to create a continuous flow of water, converting environmental heat into gravitational potential energy.

2. Theoretical Framework and Hypothesis

The core hypothesis is based on the van 't Hoff formula for osmotic pressure ($\Pi = cRT$). In a symmetrically designed U-tube with a central electrolyte solution chamber flanked by pure water chambers, an applied electrostatic field disrupts the symmetry of ion concentrations near the two semipermeable membranes. This results in differing osmotic pressures:

- At the membrane with a higher local concentration of impermeable ions, a higher osmotic pressure (Π_{high}) should draw water in (osmosis).
- Simultaneously, the fixed volume of the central chamber necessitates that water is expelled through the opposite membrane, where the local ion concentration and osmotic pressure (Π_{low}) are lower (reverse osmosis).

This process should create a stable hydrostatic imbalance (Δh) between the two pure water columns, maintained by ambient thermal energy. A gravity-driven water flow between the columns could then perpetually extract work as the system absorbs heat to restore Δh .

3. Experimental Progress and Validation

3.1 Initial Experiment (2017):

The author first proposed this theory and reported preliminary experimental results online (ScienceNet.cn blog, "The Theory and Experiment of Constructing a Perpetual Motion Machine of the Second Kind Using Osmotic Pressure"). The setup used an external power supply to create an electrostatic field via insulated electrodes, observing a sustained water level difference and continuous droplet flow.

3.2 Independent Verification and Improvement (2024):

A team led by Mr. Demin Huang conducted validation experiments. Crucially, they improved the design by replacing the external electrodes with an inherently charged nanofiltration (NF) membrane, generating the required field internally. This modification:

- Achieved a significantly larger water level difference (2.8 m vs. the original experiment).
- Eliminated potential artifacts from leakage currents in the original electrode-based setup.

Subsequently, Dr. Jing Fan independently verified the repeatability and authenticity of Huang's improved experiment.

3.3 Technical Limitations and Prospects:

Current experiments use commercially available reverse osmosis (RO) and nanofiltration (NF) membranes, which are not ideal—they allow some solute leakage (especially the NF membrane). The observed hydrostatic imbalance (NF side水位 lower than RO side) persists despite this leakage, suggesting the effect is robust. The development of an "ideal semipermeable membrane" with perfect ion selectivity (e.g., track-etched membranes with ultra-uniform pores or graphene-based filters) is identified as the critical technological hurdle for practical application. Overcoming this could unlock a potent, ambient thermal energy harvesting technology.

4. Results and Discussion

4.1 Challenge to the Chemical Potential Theory:

The standard explanation for osmotic pressure, based on chemical potential (or free energy), cannot adequately explain the observed phenomena in an ideal system. According to this theory, the chemical potential difference across a membrane drives osmosis. In the ideal system with perfect membranes, the chemical potential in the central chamber remains constant. Therefore, the theory's adherents often argue that no sustained water level difference should occur, creating a logical contradiction with the experimental results. The measured macroscopic energy output, absent chemical potential change, must originate from another source—environmental heat.

4.2 Implications for Thermodynamics:

The author asserts unwavering belief in the first law of thermodynamics (energy conservation). The results, if validated with ideal membranes, would not violate energy conservation but would indicate a limitation of the second law in systems capable of rectifying molecular thermal motion. Any such rectification mechanism could, in theory, form the basis of a perpetual motion machine of the second kind with 100% heat-to-work conversion efficiency within its operational framework.

4.3 Practical Potential and Scaling:

The experimental system currently has low power output due to high flow resistance in commercial RO membranes. However, its power density (power per unit membrane area) is already considered significant. The system can be scaled in series (to increase hydraulic head for power generation) and in parallel (for high-volume energy production). Potential applications include integration into buildings for simultaneous cooling and electricity generation.

5. An Unsolved Puzzle

A critical unresolved discrepancy exists between theoretical predictions and experimental observations regarding the direction of the water level difference:

- **2017 Experiment (Na₂SO₄ solution, external electrodes):** Theory predicted the anode side (attracting SO₄²⁻) would have lower local ion concentration and lower osmotic pressure, thus experiencing reverse osmosis and a higher water level. The experiment observed the opposite.
- **2024 Experiment (Citric acid, charged NF membrane):** Theory predicted the charged NF membrane (repelling citrate anions) would have a lower local ion concentration and lower osmotic pressure, thus experiencing reverse osmosis and a higher water level. The experiment again observed the opposite (NF side水位 lower).

While the existence of the effect itself is robust and verifiable, the consistent reversal of its direction presents a significant theoretical puzzle. The root cause of this discrepancy remains unknown and is presented here for scholarly discussion and resolution.

6. Conclusion

Experimental evidence suggests that a system utilizing electrostatic fields and semipermeable membranes can generate a sustained hydrostatic imbalance from ambient heat, challenging the conventional interpretation of the second law of thermodynamics in this specific context. The development of an ideal semipermeable membrane is crucial for practical application, promising a vast, sustainable energy source derived from environmental heat without contributing to global warming. However, a fundamental puzzle regarding the direction of the observed flow must be solved to achieve a complete theoretical understanding. This work invites further independent verification, theoretical refinement, and investigation into the nanoscale rectification of thermal motion.

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