# MagnaDip Kit: A User-Friendly Toolkit for Streamlined Fabrication of Electromagnetic Responsive Textiles


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## ABSTRACT

Smart materials play an essential role in enhancing the efficiency and diversity of human-computer interaction (HCI). This paper focuses on the domain of flexible smart materials. We introduce MagnaDip Kit, a toolkit designed for creating magnetic textiles, aiming at democratizing the innovation of new materials, facilitating the wider adoption of smart materials in everyday applications. The MagnaDip Kit ensures a straightforward and user-friendly manufacturing process, and serves as a resource for designers to employ smart materials in prototypes. Combining interdisciplinary knowledge from materials science and design, we aim to provide a tangible production experience, enabling the expansion of novel interaction modalities beyond traditional computing. Based on the toolkit's output, we further integrated the characteristics of electromagnetic responsive textiles to create a light-responsive interactive prototype, demonstrating one of the applications of smart materials. Relying on CHI2024, we seek feedback from an international audience to refine the toolkit and conduct additional workshops.



## CCS CONCEPTS

• **Human-centered computing** → Human computer interaction (HCI); Interactive systems and tools; User interface toolkits.

## KEYWORDS

Magnetic Textile, Electromagnetic Responsive, Smart Material, Toolkit

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## 1 INTRODUCTION

The utilization of materials has marked the human societal advancement from the Stone Age to the New Metallurgy Era. In recent years, the application of smart materials elevates the human-material interaction to a new level [14]. These materials, characterized by their adaptive properties [2], include shape memory alloys [13], ferrofluids [6] and optical fibers [9], etc. Within Human-Computer Interaction (HCI), smart materials demonstrate considerable potential in enriching interaction modalities, environmental sensing, and innovative interface design, notably in deformable interfaces [5] and smart wearables [11, 16]. However, the complexity of their production [3] restrict their widespread application in interaction design.

As a subset of smart materials, magnetic materials [12] exhibit robust magnetic characteristics [15] and functionalities including magnetostriction and magnetic recording [4]. Therefore, their application extends to electromagnetic shielding and magnetic therapy healthcare [10, 17]. In HCI, wearable devices combined with textiles, can utilize magnetic fields instead of power sources, offering users a more convenient and safer interaction interface [7]. However, the current preparation of magnetic textiles is limited to laboratory environments [18], making it difficult for the general public to understand and get access. Therefore, we aim to provide manipulable tools for making such electromagnetic responsive textiles, promoting their application in everyday life. In this study, we focus on providing designers and stakeholders with simple and rapid method of preparing magnetic textiles, enabling them to use our toolkit to quickly produce materials, to enhance interactive design possibilities.

Prior research [19] has established that refining the preparation processes for magnetic fluids and the dyeing of magnetic textiles can still ensure their functional efficacy. These textiles are viable for crafting sustainable and creative interfaces or artworks, such as magnetic wall coverings, thereby offering designers a source of inspiration for incorporating magnetic textile into HCI. The toolkit we propose enables practical production experience, fostering creativity and making advanced materials more accessible, thus serving as a new gateway for popularizing materials science. We also demonstrated a potential HCI application based on the toolkit's output, wherein light is utilized as a trigger to control the morphological changes of electromagnetic responsive textiles.


**Figure 1: (a) The preparation experiment. (b) The flow experiment. (c) Electromagnetic induction effect test. (d) Formulation confirmation.**

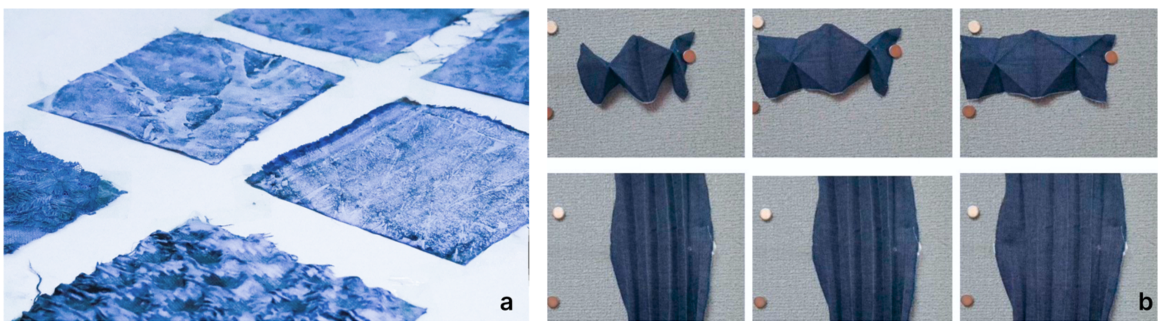


**Figure 2: (a) Electromagnetic responsive textile (combined with blue dye). (b) Electromagnetic responsive textile maintains the characteristics of the original fabric and has magnet absorption.**

The toolkit is innovative in two aspects: first, it moves electromagnetic responsive textiles away from being confined to elite domains. MagnaDip Kit simplifies the creation process based on existing methodologies, enabling users to create new materials in an intuitive and accessible manner. Second, users are allowed to experiment with manual or intelligent hardware techniques to create interactive prototypes with electromagnetic capabilities. This novel approach to material creation not only stimulates designers' creativity and curiosity in smart material innovation but also introduces a new methodology for incorporating smart materials into the field of interaction design.

## 2 THE CRAFTING APPROACH TO MAKING

Refined through numerous explorations and trials, our production technique ultimately streamlined the creation of magnetic fluids [19]. This advancement serves as a reference for exploring simpler impregnation reagents and more functional applications of electromagnetic responsive textiles. After continuous iterations and experimentation with the production process and formulations (see Figure 1), we determined the optimal magnetic fluid formula: 15g $N_1$ micron $Fe_3O_4$ 、5g CC388A toner, 15ml 99% alcohol, and 30ml distilled water. Methods such as dip dyeing [1] and nano spraying [8] are employed. Based on an immersion method, where the fabric is soaked in the magnetic fluid dye solution, and complemented by secondary spraying (nano spraying), we succeeded in creating magnetic textile (see Figure 2(a)). This kind of textile maintains the magnetic properties while preserving the softness of the fabric post-dyeing (see Figure 2(b)). Additionally, its functionality withstands various treatments such as folding, cutting and sewing [19]. The user-friendly formulation of the magnetic fluid facilitates its preparation in everyday settings, allowing seamless integration with fabric dyes to produce electromagnetic responsive textiles.

## 3 THE DEVELOPMENT OF MAGNADIP KIT

### 3.1 Toolkit Design

Based on the production technique of magnetic textiles, we developed MagnaDip Kit (see Figure 3(a)). The toolkit facilitates three primary processes: the creation of magnetic textiles, dyeing, and

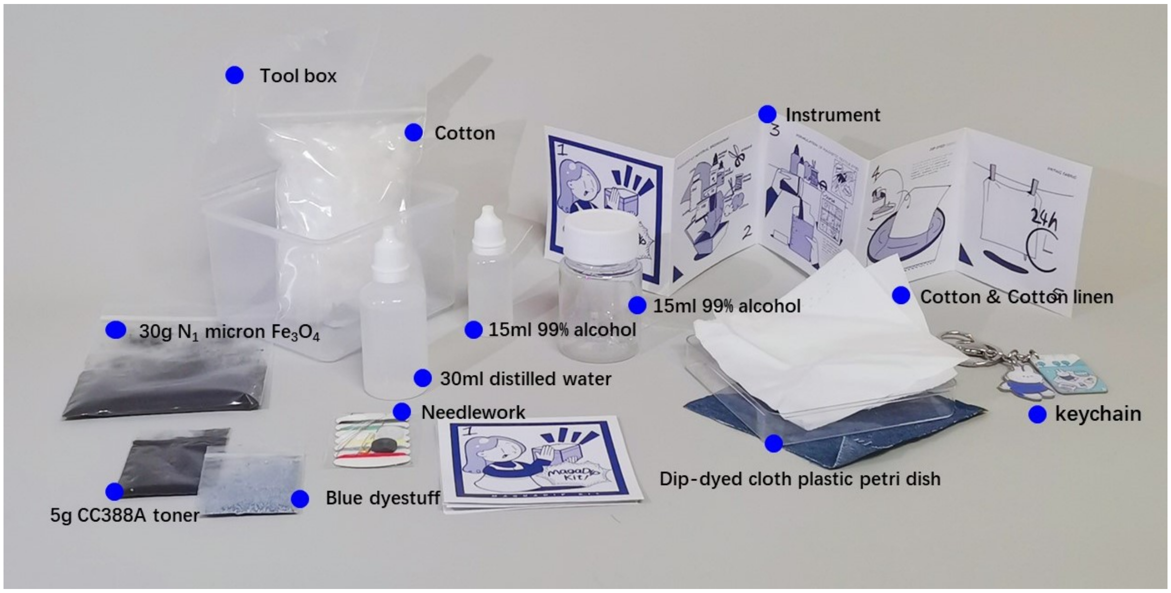


**Figure 3: MagnaDip Kit toolkit.**

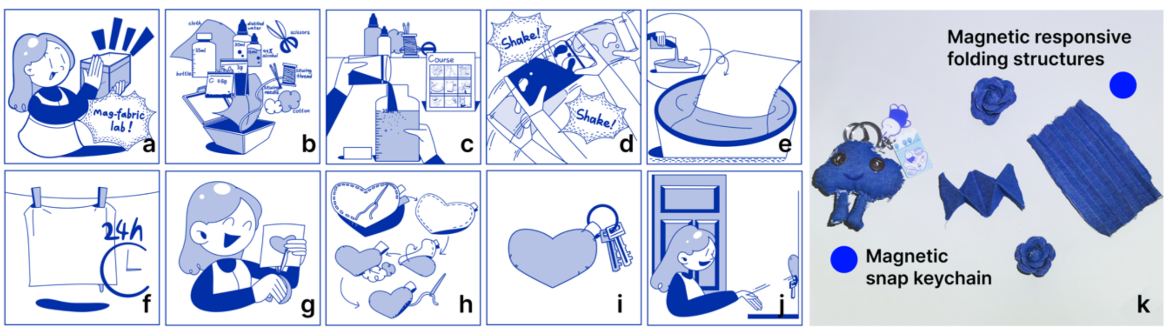


**Figure 4: The storyboard and output of MagnaDip Kit. (a) Get access to the toolkit. (b) Take out tools. (c) Prepare the solution according to the instruction. (d)Shake vigorously (to make magnetic fluid textile dye). (e) Dye the cloth. (f) Dry naturally (24 hours). (g) Making the magnetic prototype. (h) Sew the textiles. (i) The completed prototype. (j) Practical application. (k) Output.**

the development of simplified prototypes. The kit primarily contains pre-measured ingredients for the formula. To produce an enhanced magnetic effect on the textile, we further provide a nano nozzle sprayer. Afterwards, to augment the dyeing process, a variety of fabric dyes in different colors, such as blue, green, and black are included. The dye needs to be added to the dye sprayer and applied twice to ensure that the magnetic fluid solution is uniformly distributed within the fabric fibers. Each kit is also equipped with a transparent vessel to mix the magnetic fluid solution with the fabric dye, ensuring uniform color distribution and providing a clear view of the mixing process. Besides, the kit also comprises a piece of cotton linen and a piece of cotton fabric, each measuring 10cm x 10cm, which can be conveniently placed in a dye tray for effortless dyeing. Supplementary tools, such as scissors, are also provided, empowering users to leverage both the material properties and their ingenuity for DIY fabrication. The enclosed illustrated steps (see Figure 4) can assist users in constructing a simplified magnetic prototype (see Figure 3(b)). In the context of fostering the application of new materials, our toolkit has the potential to broaden the field to designers and stakeholders from varied backgrounds. The MagnaDip Kit can invite participants to fully exercise their creativity and investigate the functional potential of amalgamating magnetic fluid materials with textiles.

### 3.2 Design Application

Figure 5 illustrates the potential application of the produced textile in the realm of interactive technologies. We present a prototype showcasing one such application. Utilizing Arduino-based intelligent hardware in conjunction with the electromagnetic-responsive characteristics of the textile, a prototype responsive to light variations has been devised. Upon detection of elevated light levels

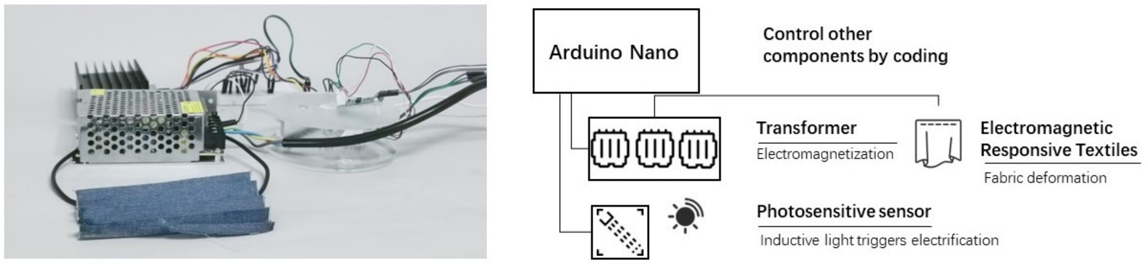


**Figure 5: Light-responsive prototype, utilizing light as a trigger to control the prototype's electrical activation, resulting in the deformation of electromagnetic responsive textile.**

by the light-sensitive sensor, the prototype activates, creating a magnetic field. This field induces a transformation in the electromagnetic responsive textile, causing it to shift from a folded state to an expanded configuration.

## 4 PLAN FOR THE INTERACTIVITY

The primary objectives of the MagnaDip Kit are to promote the prominence of new materials and inspire users' curiosity, thereby effectively encouraging designers and stakeholders to actively employ smart materials in devising novel applications. We will provide an online demonstration of the MagnaDip Kit, which encompass two segments: material fabrication and prototype creation. During the exhibition, the MagnaDip Kit will also be accessible. Participants can fabricate magnetic textile material and develop creative designs at our booth, where we will capture the resultant works through photography. We will also provide pre-fabricated textiles and interactive prototypes for direct exploration of smart material properties. Concurrently, during and post CHI 2024, we will disseminate details about the kit's materials, production instructions, and interactive videos, enabling all viewers to independently partake in the crafting process. Similarly, we envision users engaging freely in creative design, exploring the extensive potential of magnetic textiles in intelligent interaction.

## 5 CONCLUSION AND FUTUREWORK

This paper introduces MagnaDip Kit, a toolkit designed to facilitate the creation of electromagnetic responsive textiles in everyday settings. By integrating materials with design method, we aspire to broaden the accessibility of smart materials, contributing to more innovative interactive designs. We developed interactive design prototypes using the produced textiles, preliminarily validating the efficacy of this fabrication technique and expanding the scope of HCI methods. Subsequently, we plan to conduct offline workshops, inviting participants from various backgrounds to experiment with the toolkit. This will enable us to gather user feedback and assess the MagnaDip Kit's effectiveness in sparking curiosity and creativity in the crafting of smart materials. Moving forward, we intend to continuously refine the toolkit and contribute further to the application of smart materials in the realm of HCI.

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