Comment

Can e-textiles make their way into mass production?

Ramses V. Martinez

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Imagine a future in which your garments are intelligent, expressive and transform the way you perceive and communicate with your environment. This is the promise of e-textiles. E-textiles could revolutionize healthcare, communication and our relationship with technology. However, their sustainable commercialization requires a comprehensive approach that involves scientific advancements and ethical and societal evaluation.

Electronic textiles, or e-textiles, seamlessly blend traditional fabrics with cutting-edge electronics to create clothing that transcends its conventional role of merely covering our bodies. E-textiles could revolutionize the interactions between humans and machines in fields such as healthcare, sports, fashion, entertainment and defence, where they can monitor vital signs, track movements, display information, change colours and, eventually, augment the performance and enhance the experience of the wearer[1]. Although e-textiles are poised to transform the way we interact with the world around us (through sensing, computing and communication), the prospects for their large-scale commercialization are constrained by a web of scientific, ethical and societal challenges that need to be addressed urgently. By addressing these challenges, we can pave the way for the successful integration of e-textiles into our daily lives[2].

First, the production of durable, fabric-like electronics requires the development of methods for the synthesis of nanomaterials — necessary to improve the physical properties of conventional textiles — and fabrication processes compatible with current high-throughput textile technologies[3]. Second, the network of sensors embedded in e-textiles requires power to uninterruptedly collect and transmit data to the wearer or their surroundings. Various strategies have been explored to address this challenge, including harvesting energy from the wearer's motion or using the ubiquitous radio and WiFi signals present in our environment[4]. However, storing this energy necessitates the development of lightweight, durable, safe and rechargeable batteries. Third, e-textiles must withstand regular washing and drying cycles without losing their electronic properties. For example, batteries should be waterproof to survive washing cycles and heat-resistant to withstand ironing temperatures. Fourth, the production and disposal of e-textiles should have minimal effect on the environment. The fashion industry is already under scrutiny for its ecological footprint, and materials commonly used in electronic circuits and batteries are often toxic and difficult to recycle[5]. Therefore, as e-textiles become more sophisticated and widely adopted, it is essential to develop sustainable materials, efficient manufacturing processes, and responsible disposal practices to minimize their environmental impact. In addition, in the healthcare sector, e-textiles must be meticulously designed to prioritize wearer safety and comfort while simultaneously providing accurate health parameter monitoring.

The potential of e-textiles to revolutionize medical attention motivates research efforts focusing on the development of new biomedical e-textiles and their validation in clinical settings. Owing to their large contact area with the user, e-textiles are excellent platforms to host miniaturized biosensors that can track the physiological, biochemical and metabolic levels of the wearer[6]. Moreover, the integration of artificial intelligence with e-textiles holds immense potential, enabling smart clothes to gather and analyse data, potentially identifying diseases in their early stages and thus reducing healthcare costs and improving quality of life[7]. There is also much excitement about the development of personalized medical treatments where the patient is diagnosed according to the long-term measurements collected by e-textiles. The effectiveness of medical treatments could also be automatically assessed by smart clothing without the need for laboratory tests or frequent visits to the doctor, enabling near-immediate optimizations of the treatment according to the real-time recovery of the patient. However, the incorporation of e-textiles into healthcare is hindered by the need for standards that can accurately correlate non-invasive skin-level readings with traditional laboratory results. Moreover, many countries lack a clear regulatory framework for e-textiles, and it is unclear how they will be classified[8]. This uncertainty creates a barrier for companies developing e-textiles for healthcare use. Despite these challenges, as these technologies continue to mature and the regulatory landscape becomes clearer, we can expect to see e-textiles having an increasingly important role in reducing the socio-economic burden of healthcare.

The commercialization of e-textiles also brings forth a web of ethical considerations as privacy and data security are paramount. As soon as our clothing becomes intelligent, it will continuously collect and transmit sensitive information about our bodies, moods and daily lives. Who owns these data, and how are they protected? The e-textile industry must establish robust data governance frameworks to ensure wearers' privacy. Indiscriminate sharing of personal information can lead to abuse, such as targeted advertising, profiling and even selling data to third-party companies, leaving users vulnerable to fraud and scams. In the context of health monitoring e-textiles, the stakes are even higher. These garments could continuously collect biometric data, providing a detailed insight into our health and lifestyle. The misuse of such data could lead to new forms of discrimination, making it imperative to weave ethics into the very fabric of e-textiles. Thus, e-textiles require governments and regulatory agencies to be proactive in shaping policies that encourage innovation and commercialization while safeguarding the rights and safety of their users. Comprehensive measures addressing intellectual property rights, safety and quality standards, and data privacy regulations are crucial in this rapidly evolving field.

The rise of e-textiles could further challenge traditional textile industries in regions such as the Rust Belt in the USA, the Lancashire cotton region in the UK, and textile hubs in India, which are already struggling owing to globalization and automation. This could lead to increased job losses and factory closures. Therefore, governments should develop strategies to retrain and support workers affected by this transition.

As smart textiles become more accessible, their capability to augment the perception, performance, and communication of the wearer with the environment could exacerbate societal inequalities. Affordability, accessibility and inclusivity should be the core of our development and commercialization efforts. We must ensure that e-textiles do not create a divide between those who can afford them and those who cannot. The widespread adoption of e-textiles will not arrive until society recognizes that clothing is not just a passive layer but an active part of our daily lives. Our attire will then evolve into our primary health monitors, systems that warn us of impending dangers, and platforms for interactive art and communication with machines and other humans. This transformation will seamlessly bridge the gap between the digital and physical realms.

Unravelling the potential of e-textiles requires the synergy of diverse fields, from fashion to technology and from ethics to policy. We must bridge the gaps between these disciplines to create a holistic approach to e-textile development and commercialization. Universities, research institutions and industries should foster interdisciplinary collaboration involving materials scientists, engineers, fashion designers and healthcare experts. Funding agencies should prioritize e-textile research and support projects that address the technical aspects, but also the ethical and societal dimensions.

Do we dare to dream of a world where our clothing is more than mere attire? Can we envision a future in which our garments are intelligent, expressive and transform the way we perceive and communicate with our environment? Let us not squander the potential of e-textiles, or allow bureaucracy or complacency to hinder the progress of a technology that can democratize access to healthcare. We stand on the brink of a new era that is increasingly dominated by artificial intelligence. As we navigate this transformative period, it is our shared duty to ensure that e-textiles are used in a thoughtful and ethical manner. This approach will enable us to progress as a society in which an individual's information is harnessed for the collective good. Let us weave a future where e-textiles enrich our lives and redefine our relationship with technology, clothing and society. The grand tapestry of e-textiles awaits our creative threads. It is time to start weaving.

Ramses V. Martinez [1,2] ✉

[1]School of Industrial Engineering, Purdue University, West Lafayette, IN, USA. [2]Weldon School of Biomedical Engineering, Purdue University, West Lafayette, IN, USA.
✉e-mail: rmartinez@purdue.edu

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Acknowledgements

Competing interests

The author declares no competing interests.