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Evaluating Sustainable and Cost-Efficient Alternative Processes for Dye Application and Adherence in the Fashion Apparel Industry

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BACKGROUND: The Problem

Sustainability: eco-friendly, ethical, & economically sustainable production[14]

Environmental & Health Issues

The fashion Industry is the 2nd most polluting industry on Earth next to oil[2]

- It contributes to 3-10% of CO2 emissions,[1] 35% of microplastic pollution in the ocean,[1] and more

Textile dyeing procedures

- Cause water shortages and produce contaminated wastewater[3,5]
- Utilize dyestuffs & additives containing chemicals harmful to human and animal health[3,5]

Socioeconomic Challenges

- Economic challenges including financial burden on producers,[5] extra time and resources required,[5] lack of profitability,[4,6] consumer preferences,[7] and lack of visible supply chains[7] make transition to sustainable production difficult
- Sociological challenges including the additional emotional labor required of sustainable fashion producers[5] & lack of consumer awareness and concern[8] add difficulty to transition

DISCUSSION: The Solution

Sustainable & Cost-Efficient Alternative Dye Application & Adherence Methods

- Sustainable & cost efficient alternative dyeing methods are evidently available (see table 1)
- Such methods can be profitably adopted & used individually or in combination to create sustainable and profitable dyeing processes in the fashion textile supply chain
- Methods are not limited to those in table 1— Table 1 highlights some promising methods— other alternative processes exist but many need more research

FINDINGS FROM ANALYSIS OF LITERATURE

Table 1: Attributes of Sustainable and Cost-Efficient Alternative Dye Application and Adherence Processes

Dyeing Method	Water Use	Toxicity	Energy Use	Cost-Efficiency	Dye Outcome	Industrial Viability
Ultrasonic Energy Assisted Dyeing	Waterless[3]	Reduction in dye & chemical concentration used[10]	Less energy; Renewable energy[3]	Lower cost[9]	Increased color depth, Reduced processing time;[9] improved quality[10]	Cost-efficient; Already used industrially in other industries; Viable for industrial use in dyeing[10]
Super-critical Carbon Dioxide Assisted Dyeing	Waterless[3]	Nontoxic;[11] No wastewater[3]	Less energy[3]	Lower cost[3,11]	High dye uptake; high color yields[3,12]	Cost-efficient; Easily obtainable;[11] Potential for industrial use[12]
Enzymatic Pre-treatment	Conserves water; Cleans wastewater;[3] Could use 0 water used with scCO2	Less effluent toxicity[13]	Less energy[13]	Lower cost when replacing wetting agents[13]	Improved dyeability on industrial scale;[3] Reduced fiber damage[13]	Already applied to industrial scale at different processing stages;[3] Potential for industrial use[13]
Liposome Application	Waterless when used with super-critical fluid	Nontoxic[3]	Less energy[3]	Lower cost[3]	Enhanced textile quality;[3] Enhanced color yield[3]	Cost-efficient; Potential for industrial use[3]

Socioeconomically Viable Transition To Sustainable Production Methods

- The reDesign canvas facilitates viable sustainable production from start to finish: it is a tool to be used by sustainable fashion entrepreneurs which lays out a comprehensive design plan accounting for everything along the apparel life cycle needed to produce sustainably[14]
- Demand must be increased for sustainable fashion in order to increase profitability— involves raising consumer awareness and concern, marketing clothing strategically[14]— there is already notably high and growing awareness and demand[15]
- A transparent and traceable supply chain following sustainable procedures must be established[6,14]
- Working with stakeholder clusters interested in resolving sustainability issues should be prioritized for funding[6,14]

Circular Design & Economies

Have you **considered all components** (e.g. zippers, labels, buttons etc.), **raw materials** & how they are **manufactured?**
What are the **material flows** of all considered components including textiles?
Have you considered the **biological and technical cycles** that the **materials &/or components** belong to?
Can you avoide or **eliminate hybrids**?
Are materials **toxic** or going to **waste?**
Do **better alternatives** exist & are feasible?
What are the **best available technologies (BAT)?**
Do materials **add value** to bioshere as **biological nutrient?**
Are materials **returned** to business & **cycled?**
Can materials be **used by other** others to **create value?**
Does the circular opportunity **reinforce** the brands **aspired value?**
Can you turn a **product** into a **service?**

3 Strategies:
Slowing resource loops
Closing resource loops
Narrowing resource flows or resource effciency

Circular cycles:
Technical cycle
Biological cycle

Figure 1: The Circular Design & Economies Section on the reDesign Canvas[14]

REFERENCES