white cycle

STRATEGIC INTELLIGENCE BULLETIN N°11

Understanding the PFAS directive's effect on textile recycling in Europe

August 2025

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White Cycle project has received funding from the European Union's Horizon 2020 research and innovation program under Grant agreement no.101036908.

News & EU regulations

Recent progress & regulations on textile recycling in the EU

EU-wide regulations are accelerating the scale-up of textile recycling. As of January 2025, all EU member states are required to implement separate textile waste collection systems and Extended Producer Responsibility (EPR) schemes, mandating brands to manage the full lifecycle of textiles, including waste reduction, reuse, and recycling. New legislation also bans incineration of textiles and pushes for increased recycled content in products. These measures, combined with investments in advanced sorting and depolymerization infrastructure, have triggered major industry and policy shifts in 2025. However, challenges persist in ramping up collection capacity and harmonizing EPR schemes across countries as a critical step to achieve EU circularity goals for textiles.

More information here.

PET & polyester recycling initiatives

As regulatory frameworks tighten, PET (polyester) recycling efforts are advancing alongside textile recycling. The EU is prioritizing chemical recycling and closed-loop systems to ensure that PET waste originating from both packaging and textiles re-enters the production cycle. New research highlights significant environmental benefits if EU textile-to-textile recycling rates increase to 10% by 2035, such as major reductions in carbon emissions and water use. Policy incentives and brand commitments are fueling these developments, but robust infrastructure and traceability standards remain essential for lasting impact.

More information here.

Major textile recycling legislation in 2025

2025 marks a pivotal year for textile recycling in Europe. The EU Waste Framework Directive now mandates that all member states establish separate textile waste collection systems, with implementation deadlines hitting in January 2025. Extended Producer Responsibility (EPR) and Ecodesign for Sustainable Products Regulation (ESPR) require brands to finance and manage textile waste reduction, recycling, and sustainable product design. Incineration bans and recycled content mandates further strengthen the regulatory landscape. These policies are driving an industry-wide push for better sorting technology, increased system transparency, and large-scale recycling plant investments.

More information here.

Recent industry investments & innovations

Significant investments and cross-sector collaborations have shifted Europe from discussions to action in large-scale textile recycling. 2025 has seen the launch of new chemical recycling plants, expansion of advanced sorting infrastructure, and the formation of public-private partnerships. Efforts focus on “true circularity,” where post-consumer textiles are recycled back into high-quality fibers for new garments. These advancements are supported by new rules on traceability, ecolabelling, and minimum recycled content for branded products.

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More information [here](#).

Business and economic opportunities

A 2025 Boston Consulting Group report points to significant value creation from scaling textile waste recycling and reusing PET and other polymers. As consumers and policymakers demand sustainable solutions, brands investing early in recycling infrastructure and circular product design can achieve cost savings, improved resource efficiency, and enhanced brand value. However, companies must navigate rapid regulatory change, technology investments, and harmonization of EPR compliance across markets to capture these benefits.

More information [here](#).

Overview of the current EU textile regulatory environment

The EU is committed to harmonizing textile recycling rules across all member states in the coming years, including a wider rollout of textile EPR and digital product passports. Attention is focused on bridging the gap in collection and sorting capacity, developing supply chain traceability, and ensuring compliance with ecolabelling and recycling content standards for all textiles placed on the market. Close monitoring and periodic policy reviews in 2025 and beyond will be key to ensuring successful implementation and the transition to a circular textile economy.

More information [here](#).

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Focus of the strategic bulletin n°11: Understanding the PFAS directive's effect on textile recycling in Europe

Introduction

Per- and polyfluoroalkyl substances (PFAS) have been extensively used in textiles for decades to provide water repellence, stain resistance, and durability [41]. However, these "forever chemicals" present significant challenges for Europe's transition to a circular textile economy. The European Union's regulatory response through various directives and the proposed universal PFAS restriction under REACH creates complex implications for textile recycling processes, industry compliance, and the broader circular economy objectives outlined in the EU Strategy for Sustainable and Circular Textiles.

Key PFAS regulations affecting textiles in the EU

The European regulatory landscape for PFAS in textiles operates through multiple interconnected frameworks. The European Chemicals Agency (ECHA) announced in February 2023 a comprehensive proposal to restrict more than 10,000 PFAS substances under the REACH Regulation, submitted by Denmark, Germany, the Netherlands, Norway, and Sweden [3]. This universal restriction approach represents a significant departure from previous individual substance-based regulations.

Currently, specific PFAS compounds are already restricted in EU textiles. PFOS has been banned since 2008, PFOA since 2020, and PFNA and PFHxS since 2023 [41]. However, these substances may still be present in textiles sold before the restrictions entered into force, creating ongoing challenges for recycling operations.

The EU's Chemicals Strategy for Sustainability outlines an ambition to phase out all non-essential uses of PFAS, while the EU Strategy on Circular and Sustainable Textiles aims to make textiles more sustainable but does not include specific focus on PFAS [41]. This regulatory fragmentation creates complexity for industry compliance and recycling operations.

Impact on textile recycling processes and circular economy

PFAS presence in textiles creates substantial barriers to circular economy objectives. Textiles account for approximately 35% of total global PFAS demand, with an estimated 41,000 to 143,000 tonnes of PFAS used in the EU textile sector [41]. The persistence and bioaccumulative properties of PFAS mean they can contaminate recycling streams and end up in new products without proper identification and separation.

The EU's mandatory separate collection of textile waste, which began on January 1, 2025, significantly increases the volume of textiles entering waste streams [45]. However, PFAS contamination complicates this process, as contaminated textiles may render entire batches unsuitable for recycling. Research indicates that the majority of treated textiles would be considered hazardous based on PFAS

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content, potentially creating 1.7 million tonnes of hazardous and unrecyclable textile waste in the EU as of 2018 [27].

The presence of PFAS in textiles can hinder material reuse and recycling by making these processes "substantially more complicated, costly, environmentally impactful, or energy- or resource-demanding" [44]. This directly conflicts with the EU's circular economy goals and the waste hierarchy principles that prioritize reuse and recycling over disposal.

Main challenges for textile recyclers

Textile recyclers face multiple interconnected challenges related to PFAS contamination. The primary challenge is identification and sorting of PFAS-containing textiles, which is expensive and generally not feasible through standard chemical analyses [41]. Visual identification procedures are highly uncertain since PFAS presence cannot be reliably determined through visual inspection.

Current practices are insufficient to trace PFAS content in after-use and waste stages, and the EU currently lacks technologies for general large-scale, efficient, and cost-effective identification and sorting of textile waste containing PFAS [41]. This creates a significant bottleneck in recycling operations, as recyclers cannot easily distinguish between contaminated and clean materials.

The fragmentation in waste management and recycling processes further hinders effective management of post-consumer waste [7]. Collection and sorting challenges persist, with elevated efforts required in collection, sorting, and pre-processing to address PFAS contamination effectively.

Compliance requirements and timelines

The regulatory timeline for PFAS restrictions creates both immediate and long-term compliance challenges. The proposed universal PFAS restriction is currently under evaluation by ECHA committees, with specific considerations for Textiles, upholstery, leather, apparel, and carpets (TULAC) [44].

Individual member states are implementing national restrictions while awaiting EU-wide action. France has proposed a national PFAS ban that includes textiles, with exemptions for protective clothing for security professionals. Denmark has expressed intention to ban PFAS in clothing, shoes, and impregnation products for consumer sale [41].

The Ecodesign for Sustainable Products Regulation (ESPR) will establish performance and information requirements for textiles, including restrictions on substances of concern that impede recycling [44]. These requirements will be implemented through delegated acts, with the first requirements for apparel textiles not expected before mid-2027 at the earliest.

Extended Producer Responsibility (EPR) schemes for textiles, expected to be implemented 18-30 months after the Waste Framework Directive revision enters force, will include eco-modulation criteria based on environmental impacts, potentially penalizing PFAS-containing products through higher fees [44].

Solutions and alternatives being developed

The development of PFAS alternatives for textiles shows promising progress. According to the REACH restriction dossier, technically feasible alternatives are available for the majority of textile categories, including home textiles, consumer apparel, professional sportswear, and footwear [41]. However, alternatives remain lacking for some specialized applications, particularly certain types of personal protective equipment requiring flame retardancy and high-performance membranes for medical applications.

Innovative recycling technologies are being developed to address PFAS contamination. Research demonstrates cellulose nanocrystal-in-solvent processing systems for efficient one-pot upcycling of commercial polymeric PFAS, offering sustainable methods to overcome regulatory challenges [8]. These closed-loop processing systems can recollect and reuse solvents while creating performance-enhancing agents for green energy applications.

The European Commission's Safe and Sustainable by Design (SSbD) approach, currently under development, will provide tools for industry to identify and develop safe and sustainable alternatives to PFAS for textile categories where alternatives are not yet available [41].

Digital solutions are also emerging to improve traceability. The Digital Product Passport (DPP) requirements under ESPR will enhance end-to-end traceability throughout value chains, potentially enabling better identification of PFAS-containing products [44]. Semi-automatic or fully automated sorting based on digital information solutions or X-ray fluorescence machines could improve separation capabilities, though implementation costs remain high.

Implications for textile industry and consumers

The PFAS restrictions create significant implications across the textile value chain. For manufacturers, the restrictions necessitate reformulation of products and supply chain adjustments to ensure compliance. The medical device industry faces particular challenges, as fluoropolymers like PTFE are essential for many medical applications, and the short derogation times may be insufficient for product approvals under Medical Device Regulation timelines [5].

For consumers, the restrictions may initially limit product availability for specialized applications while alternatives are developed and scaled. However, the long-term benefits include reduced exposure to harmful substances and improved environmental protection. The Human Biomonitoring for Europe initiative found that 14.3% of tested European teenagers had PFAS blood levels exceeding health-based guidance values [41].

The textile industry must adapt to new information disclosure requirements, including reporting on unsold consumer products and their disposal methods [44]. This transparency requirement may drive behavioral changes in production and inventory management practices.

Export implications are significant, as PFAS-containing textiles may face increased export restrictions under the Waste Shipments Regulation, particularly to non-OECD countries [44]. This could shift waste management burdens and require development of domestic treatment capabilities.

Implications & examples

The PFAS directive's impact on textile recycling demonstrates the complex interplay between chemical safety and circular economy objectives. The case of Italy, which implemented mandatory separate textile collection in 2022, provides valuable insights into early implementation challenges and opportunities [45].

The medical device sector illustrates the challenges of balancing safety and functionality. Essential applications like heart valves and vascular grafts rely on fluoropolymers for their unique properties, yet face potential supply chain disruptions due to PFAS restrictions [5].

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The development of alternative technologies, such as the cellulose nanocrystal processing systems, demonstrates how innovation can address regulatory challenges while creating new opportunities for sustainable materials [8]. These solutions align with both environmental protection goals and technological advancement needs.

The global nature of textile supply chains means that EU regulations will have far-reaching impacts on trading partner countries, particularly in Asia and Africa where much textile production and waste processing occurs [44]. This creates both challenges and opportunities for international cooperation on sustainable textile management.

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Scientific publications

From Waste to Value: Advances in Recycling Textile-Based PET Fabrics – MDPI, Textiles, Fatemeh Mohtaram and Peter Fojan, June 2025

Keywords: Polyethylene terephthalate; nanofiber; recycling textile waste; textile to textile recycling; electrospinning

Abstract:
The environmental burden of textile waste has become a critical challenge for sustainable development. This review explores recent developments in the recycling of textiles, especially polyethylene tereph-2 thalate (PET)-based fabrics, with a focus on fiber-to-fiber regeneration as a pathway toward circular textile production. Recent developments in PET recycling, such as mechanical and chemical recycling methods, are critically examined, highlighting the potential of chemical depolymerization for recovering high-purity monomers suitable for textile-grade PET synthesis. Special attention is given to electrospinning as an emerging technology for converting recycled PET into high-value nanofibers, offering functional properties suitable for advanced applications in filtration, medical textiles, and smart fabrics. The integration of these innovations, alongside improved sorting technologies and circular design strategies, is essential for overcoming current limitations and enabling scalable, high-quality recycling systems. This review aims to support the development of a more resource efficient textile industry by outlining key challenges, technologies, and future directions in PET recycling.

More information here.

Enhanced decolorization behaviors of colored PET textiles by supercritical carbon dioxide as part of the recycling process – Science Direct, ELSEVIER, Teng Huang, Xin Wei, Shaoqing Qu, Weizhong Zheng, Ling Zhao, Volume 222, August 2025

Keywords: Discoloration of PET textiles; Supercritical CO2; Process intensification; Kinetic model

Abstract:

Currently, most colored Polyethylene terephthalate (PET) textiles are not recycled, because the presence of dyes leads to uncontrollable coloration in chemically recycled PET products. Traditional solvent-based decolorization faces scalability challenges due to high solvent use, low efficiency, and environmental impact. This study explores $scCO_2$ to enhance solvent decolorization by reducing PET-dye interactions. An $scCO_2$-assisted decolorization process was established in a batch reactor. Optimal conditions were identified at 8 MPa, 90 °C, and solid-to-liquid ratio of 1:20, enabling 86 % disperse dye removal within 20 min. Under higher energy consumption conditions (1 h, 120 °C), the single-cycle decolorization efficiency reached 97 %. Considering the liquid phase renewal in a continuous process, repeated decolorization of the treated PET enabled complete dye removal within three cycles. The kinetics were studied with activation energy calculated. Additionally, the process did not change the structure of stripping solvents and disperse dyes, allowing for subsequent recycling and reuse.

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More information here.

Chemical degradation and recycling of polyethylene terephthalate (PET): a review – Royal society of chemistry, Zhiqiang Guo ORCID, Jin Wu c and Junhong Wang, February 2025

Keywords: Chemical degradation of PET, Alcoholysis, Hydrolysis, Aminolysis, Pyrolysis

Abstract:

Polyethylene terephthalate (PET) is one of the most common plastics, which is mainly used in food packaging and textiles. In recent years, the massive use of PET has led to the destruction of the ecological environment, and it is necessary to develop green, low-cost, and efficient recycling technologies to alleviate such problems. In this paper, we summarized the advantages and disadvantages of chemical degradation of PET in the past decade, including alcoholysis, hydrolysis, aminolysis and pyrolysis. Among them, several new catalysts have been applied to the depolymerization of plastics, such as ionic liquids, eutectic solvents, metal–organic frameworks and polyoxometalate, which not only shorten the reaction time, but also increase the yield of the product and the conversion of PET. This review emphatically introduced the conversion of PET and the yield of the product under different parameters, and clarified the direction of future research on the chemical degradation of PET.

More information here.

Development of Glycolysis Catalysts for PET Wastes Including Polyester Textiles – Springer nature, Yongjoon Kim, Taemin Jang, Hyein Hwang, Yujin Sung & Byung Hyo Kim, December 2024

Keywords: Polyethylene terephthalate (PET), Glycolysis, Catalysts, Recycle, Textiles

Abstract:

Polyethylene terephthalate (PET) is a versatile polymer widely used in textiles because of its chemical stability, mechanical strength, and ease of processing. However, the increasing consumption of PET, particularly in the textile industry, has led to significant environmental concerns owing to its resistance to degradation. To address these issues, chemical recycling methods, particularly glycolysis, have attracted attention for depolymerizing PET into valuable monomers for repolymerization. This review focuses on recent advances in catalysts for PET glycolysis, with special emphasis on their application in textile recycling. We categorized the catalysts into homogeneous and heterogeneous types and discussed their effectiveness in reducing the reaction temperatures and times, thereby decreasing energy consumption and operational costs. Although homogeneous catalysts achieved efficient depolymerization at lower temperatures, their post-reaction separation and purification steps remain challenging and costly. In contrast, heterogeneous catalysts offer simpler separation processes but require significant energy input. Research on the application of glycolytic catalysts in fiber recycling was also highlighted, considering the substantial use of PET in the textile industry. Finally, we suggested future research directions for developing cost-effective and sustainable catalysts that are applicable to PET fibers with the aim of enhancing the efficiency and environmental sustainability of PET recycling processes.

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More information [here](#).

Recovery of pure PET from wool/PET/elastane textile waste through step-wise enzymatic and chemical processing – Sage journals, ISWA, Emanuel Boschmeier, Daniella Mehanni, Andreas Bartl, Volume 43, issue 6, September 2024

Keywords: Textile waste samples, Enzyme, woollen fibrous residues, SDS–poly acrylamide gel electrophoresis

Abstract:

Textile waste is mostly incinerated because few recycling processes are available to recover valuable materials. In this work, a feasible chemo-enzymatic recycling process of wool/polyethylene terephthalate (PET)/elastane blends to recover pure PET is for the first time successfully demonstrated. Two novel enzyme formulations were selected for wool hydrolysis, whereas the recovered amino acids were quantified using high-performance liquid chromatography and two assays (Ninhydrin and Folin–Ciocalteu). Kinetic studies on the amino acid formation alongside reaction observations by scanning electron microscopy proved sufficient removal of wool within 8 hours with the new enzyme formulation, marking an acceleration compared to previous studies. Finally, elastane was separated with a non-hazardous solvent to obtain pure PET. Tensile tests on the recovered PET fibres reveal only slight changes through the enzymatic treatment and no changes induced by the applied solvent. The enzyme formulation was successfully tested on five different post-consumer wool/PET textile waste samples. This valorization approach enhances the circular economy concept for textile waste recycling.

More information [here](#).

Sustainable recycling of PET/cotton mixed waste fabrics: Mechanical decomposition and efficient component separation for reuse - Science Direct, ELSEVIER, Wang Hou, Veronika Tunáková, Shi Hu, Dan Wang, Jakub Wiener, Ludmila Fridrichová, Jana Novotná, Xiuling Zhang, Volume 149, August 2025,

Keywords: Polyester-based waste fabric; Mechanical decomposition; Particles size; Separation; Recycling

Abstract:

In recent years, the surge in production of polyethylene terephthalate, also known as polyester, has resulted in a large amount of waste polyester-based textiles. Traditional incineration and landfilling methods can cause serious harm to the environment, while existing recycling methods have deep-rooted shortcomings, making the disposal of waste polyester an urgent problem to be solved. A new mechanical recycling method for waste polyester-based fabrics is proposed in this article. The effect of cutting mill parameters (number of cutting times, cassette perforation dimension) on the size of particles mechanically decomposed from waste fabric was analyzed. For a description of the particle size, the sieving methodology was chosen. It was found that both selected factors have statistically significant effect on particle size. As the number of cutting times increases, the particle size decreases, and using larger perforation sieve cassette results in larger particle sizes. To separate and recover polyester and other components from mechanically decomposed polyester-based waste fabrics, two

methods were proposed and explored. The separation effectivity of different material components was evaluated using Fourier transform infrared spectroscopy and thermogravimetric analysis. Mechanical decomposition of polyester blend textiles offers a low-pollution and efficient recycling method, making it promising for textile waste management. This approach shows strong potential for industrial scalability, offering a feasible and environmentally friendly solution for large-scale textile waste recycling.

More information here.

Substance flow analysis of polyethylene terephthalate (PET) fiber in China - Science Direct, ELSEVIER, Resources, Conservation and Recycling, Jun Ning, Shoujuan Tang, Yingjie Fu, Guangxin Liu, Yuheng Sun, Zhengyuan Feng, Donggen Huang, Lei Shi, Volume 212, January 2025

Keywords: PET fiber; Substance flow analysis; Driving forces;

Abstract:

The flow process of polyethylene terephthalate (PET) fibers presents complex characteristics that are challenging to quantify accurately. This study quantified the flow patterns of PET fiber production, consumption, trade, and recycling during 1990–2022 and analyzed the effects of the economy, technology, and policy on the metabolic processes of PET fiber. Key findings are as follows: (1) the consumption and export of PET fiber showed an exponential growth trend due to rapid economic growth, accession to WTO, and technological progress since 2001; (2) the production of PET fiber decreased slightly during 2016–2018, affected by high-quality transformation of industry and the elimination of backward production capacity policies; (3) the increases in recycled PET fiber input after 2019, due to carbon peak, carbon neutral, and circular economy policies, have affected the formation of a new pattern of PET flow and resulted in new opportunities and challenges for the development of PET industry.

More information here.

Events

29th September 1rst October 2025 - ECOSYSTEX Conference, Gothenburg, Sweden

The third ECOSYSTEX Conference will take place as a physical event on 29 September-1 October in Gothenburg, Sweden, in partnership with RISE Institute of Sweden.

This event will bring together experts, innovators, and industry leaders to explore new technologies and business models for textile circularity.

What to expect:

- Two days of insightful discussions, networking, and collaboration
- Interactive sessions led by PESCO-UP, SOLSTICE, tExtended, and Hemp4Circularity
- A showcase by WhiteCycle, featuring their latest PET recycling innovations and sample exhibits
- Exclusive visits to the research facilities at RISE and the DO-tank centre in Science Park Borås

We are still fine-tuning the programme, and registrations will open in late spring. For now, mark your calendar and stay tuned for more details!

If your project is interested in contributing to the programme planning process or would like to co-organise a session, we welcome your involvement. Reach out to us to explore collaboration opportunities.

***More information** [here]*

1rst October 2025 - 7th European Recycling Conference (ERC), Hamburg, Germany

This year's theme: Building a competitive market for recycled materials

Co-organised with our German members, BDSV, bvse, and VDM.

Join top-level speakers from both the industry and policy-making spheres, and connect with fellow industry leaders, market analysts and journalists.

EuRIC is putting a strong focus on networking opportunities. Be sure to arrive early to take full advantage of our networking sessions and get ready to celebrate with us.

Registrations, along with the draft agenda, will be shared soon! Spread the word with your network and join us this October as we shape the future of circularity in Europe and beyond.

***More information** [here]*

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19 & 20th November 2025 - Advanced Recycling Conference, Cologne, Germany

The unique concept of presenting all advanced recycling solutions and related topics at one event will guarantee a comprehensive and exciting conference experience, including technologies such as extrusion, dissolution, solvolysis, enzymolysis, pyrolysis, thermal depolymerisation, gasification, and incineration with Carbon Capture and Utilisation (CCU).

More information here

26 & 27th November 2025 – Plastics recyclers annual meeting 2025, Valencia, Spain

Join us for two days of insightful discussions and exchanges with key actors in the plastics recycling value chain at the Plastics Recyclers Annual Meeting 2025. This year's topic is 'Facing Market Recession: Way Forward for a Competitive Plastic Recycling Industry'. Registrations for the Annual Meeting 2025 are open. Please note that a maximum of 4 representatives per company can attend the meeting.

More information here

27 & 28th November 2025 – 7th annual advanced plastics recycling conference, Berlin, Germany

We are excited to invite you to the 7th Annual Advanced Plastics Recycling Hybrid Conference, a leading global event focused on advancing sustainability and innovation in plastics recycling. Hosted in the dynamic city of Berlin, Germany, this two-day conference offers the flexibility to join either in person or virtually, bringing together industry experts, policymakers, and innovators to shape a circular future for plastics.

More information here

29 & 31rst October 2025 - Recycling Week 2025, Barcelona, Spain

The 3rd World Recycling Convention (Recycling Week 2025) is a premier international event, scheduled from October 29-31, 2025, in Barcelona, Spain. It brings together global industry experts to discuss advancements, challenges, and innovative solutions in waste management and recycling. The conference features key segments on recycling, e-waste, chemicals, and sustainable technologies, aiming to foster B2B collaborations, insightful keynote talks, and networking opportunities. By uniting recycling specialists, engineers, and industry leaders, it aims to address environmental concerns and enhance industry knowledge, driving progress toward sustainability and responsible waste management.

The 3rd World Recycling Convention is an annual global conference uniting industry leaders to advance Recycling and E-waste Management. With keynote talks, B2B meetings, and panels, it offers insights into sustainability trends. Focusing on technology-driven environmental solutions, the convention promotes collaborations, fostering industry growth. In 2025, it aims to deliver high-value knowledge exchange, empowering attendees with resources to navigate the evolving recycling landscape.

More information here

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