

Summaries from *TAPPI Journal* June 2025 and July 2025 Issues



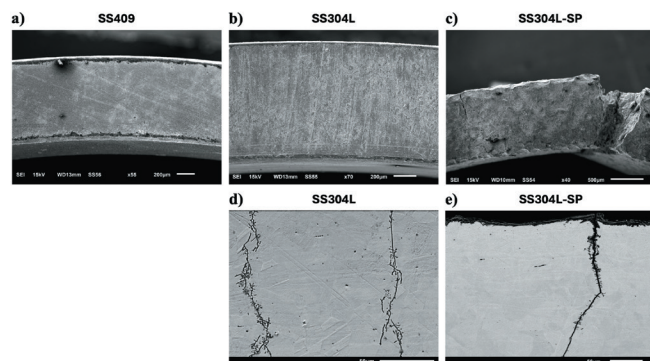
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JUNE

CORROSION & MATERIALS

Materials performance considerations in hydrothermal liquefaction conversion of biomass

Elliott Asare, Yimin Zeng, and Joseph Kish



Secondary electron images of stainless-steel U-bends after 120-h immersion in a chlorine and sulfur solution: a) SS409, b) SS304L, and c) SS304L-SP. Backscattered electron image of cracking in the cross-section: d) SS304L and e) SS304L-SP.

Hydrothermal liquefaction (HTL) is a promising thermochemical route developed to convert woody biomass and biowaste to biochemicals and bio-oils. However, the operating conditions are rather harsh to biorefinery structural metallic components. Thus, selection of suitable structural alloys for biorefinery components involves striking a balance between

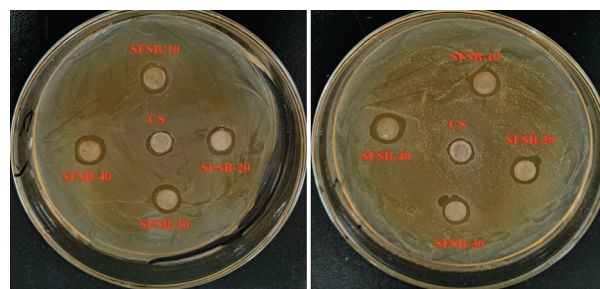
mechanical properties, corrosion resistance, and cost. Alloys currently being considered for this application include ferritic-martensitic steels and austenitic stainless steels. From a corrosion perspective in hot pressurized water, the former typically exhibits higher stress corrosion cracking resistance, whereas the latter exhibits higher corrosion resistance.

This study reviews cost-effective corrosion control strategies aimed at increasing the chromium (Cr) content for protective surface oxide formation, as screened by testing in simulated HTL alkaline water, to support materials selection and design. Corrosion control strategies include surface modification (increasing surface Cr content), alloying (increasing bulk Cr content), and stainless-steel type (ferritic vs. austenitic). Of the alloys considered (including those subjected to surface modification), ferritic stainless steels exhibit a promising balance between corrosion and stress corrosion cracking resistance, adding another family of candidate alloys for structural biorefinery component materials selection and design.

PACKAGING

The effect of *Stachys floridana* Shuttlew.ex Benth extract as an additive on the chemical properties of chitosan biodegradable film

Qingxuan Zhao, Shun Liu, Jie Li, Haitang Liu, Sheng Liu, Qian Wang, Ying Li, and Hui Wang



Bacteriostasis of *Escherichia coli* (left) and *Staphylococcus aureus* (right) indicating the inhibitory effect on bacterial growth with CS-SFSB films as opposed to CS alone, especially at higher SFSB extract concentrations.

The purpose of this study was to explore chitosan with *Stachys floridana* Shuttlew.ex Benth (SFSB) extract as an additive to prepare an active film. The authors studied the effects of the SFSB extract on the physical, antioxidant, and bacteriostatic properties of chitosan biodegradable films.

Results showed that the addition of SFSB extract significantly improved the antioxidant and antibacterial properties of the film, and its biodegradation rate increased rapidly. Compared to the control film, the water solubility was lower at 19.40 percent, the expansion degree was higher at 288.90 percent, the water vapor permeability (WVP) was 0.364 g·mm/(m²·d·kPa), the surface hydrophobicity increased, and the mechanical strength was also improved. The contact angle increased to 89.3°. In addition, as the amount of SFSB increased, the thermal stability of chitosan-*Stachys floridana* Shuttlew.ex Benth (CS-SFSB) films also increased significantly, and their ultraviolet blocking ability was gradually enhanced. The results indicate that CS-SFSB has potential as a food packaging material. This

study is conducive to the development of CS-based films and contributes to the development of new biodegradable food packaging films.

PULPING

Gap mechanics in pulp refiners

R.J. Kerekes

Studies of pulp refining have shown that a single bar impact on pulp has only a 1-5 percent probability of producing a successful refining effect. This study explores the reason why.

An analysis of refining kinetics suggested that small segments of a fiber length, about a fiber diameter in size, are treated during each impact. Measurements of localized swelling along fiber lengths caused by refining supported this finding. Based on these findings, it was postulated that force transmittal through fiber networks occurred primarily at fiber crossings. The small size of fiber diameters relative to fiber lengths accounts for the low probability of a successful refining event at each impact. This probability, and the probability of fibers being captured and impacted during passage through a refiner, account for the need for multiple bar crossings to refine pulps.

This study provides researchers with new ideas on the fundamentals of pulp refining with the aim of spurring research on this important process.

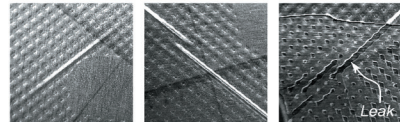
JULY

COMPOSITE LAMINATES

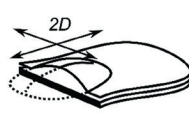
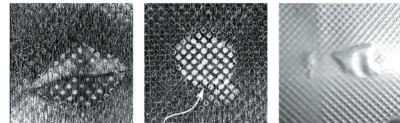
Local delamination in pharmaceutical blister packages— A thermomechanical theory on buckling of heat-sealed composite laminates in flexible packaging

Peter A. Gellerich and Lena M. Bracken

One-dimensional creases



Two-dimensional dents



Examples of local delamination defects in pharmaceutical blister packaging.

Pharmaceutical blister packages consist of cavities made from a thick polymeric form foil and a thin aluminum lid foil. Heat-sealing technology is usually used to bond the lid foil to the form foil. Occasionally, the sealed area shows buckling defects of the lid foil, which allow contamination to enter the cavity. A contaminated product is a worst-case scenario for pharmaceutical production and must be avoided.

This research discusses a thermomechanical theory on buckling defects in blister packages and derives strategies to avoid these. The theory assumes that the seal of a blister packaging behaves like a laminate of thin composite layers under compressive load. Literature research on buckling of thin laminated films, thermal behavior of polymers, and seal strength of heat-sealed polymers provides the technical and physical background to elaborate the theory. The theory has three elements: an initial condition regarding thermal load and precedent defects; a buckling condition; and a crack propagation condition. Researchers verified the theory's plausibility

using model calculations and heat-seal tests. The study concludes with strategies against buckling of heat-sealed lid foils and an outlook on other applications.

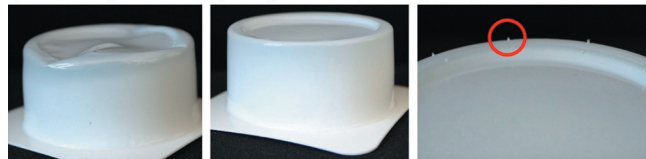
This study provides a simple approach to evaluate buckling phenomena, such as creases and dents, in thin layer laminates. Readers may use a thermal analysis like that presented to calculate the heat input of a lamination or heat-sealing process. Furthermore, readers may use the presented buckling equations to estimate if the induced thermomechanical load is critical in generating creases and dents.

THERMOFORMING

Data-efficient determination of machine-specific process windows in thermoforming using the example of PCR materials

Felix Lange, Florian Schaller, Fabian Kayatz, and Marek Hauptmann

a) '3' - incomplete b) '4' - good c) '6' - punctures



Molding stage quality categorizations showing (a) incomplete shaping of bottom radius, (b) complete shaping of cup geometry without detectable vent holes, and (c) punctures at vent holes.

In an industrial context, technicians often determine process windows for thermoplastics in thermoforming processes through time-consuming trial-and-error. This results in increased effort when commissioning new machines, implementing new technologies, or substituting sheet materials. One key reason is the lack of methods that allow for efficient, process-related assessment of material behavior and a quantitative definition of a "target state" of the heated sheet in relation to geometry and process conditions.

In this study, researchers present the In-Situ Thermoforming Characterization (ITC) method as an application-oriented approach that enables format-independent evaluation of material behavior directly within the forming station of a thermoforming system. The method was successfully applied to a material substitution case, replacing conventional virgin polypropylene (PP) with post-consumer recycle (PCR)—in this case, recycled PP (rPP)—in the production of a defined cup geometry. The results enabled the transfer of existing process knowledge from the virgin material to the recycle, thereby accelerating material qualification.

Based on the collected data, material behavior under process conditions could be mapped within the design space, making it possible to identify machine settings that deliver equivalent forming results in the test setup. Overall, the method shows strong potential for efficient and precise determination of machine-specific process windows.

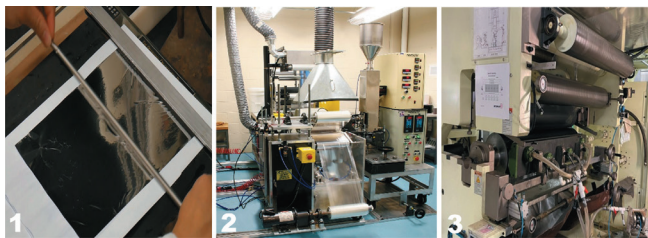
This method offers a quantitative, practical comparison of material conditions for different materials during forming. This means that empirical values and data collected using a single material with one or more formats can be used for process optimization, such as material substitution across competing materials for thermoforming applications.

PRIMERS

Adhesion with purpose: The value of primers in sustainable flexible packaging

Yong Zheng

Primers play a crucial role in flexible packaging by providing adhesion, enhancing performance, and improving the overall quality of packaging



Three-step adhesion improvement procedure using water-based primer to solve adhesion issues. Step 1: Wetting-out test; 2: Adhesion test; and 3: Extrusion coating with priming

structures. The packaging industry's shift toward more sustainable solutions brings new challenges for meeting adhesion requirements. Different types of sustainable materials, with their complicated physical and chemical properties, usually result in poor adhesion in extrusion coating or extrusion lamination—whether this is due to fast crystallization, secondary crystallization, low processing temperature, lack of functional groups, or a combination thereof. Water-based primers ensure that these innovations meet both functional and environmental standards for the packaging of tomorrow. Conventional water-based primers, including polyethyleneimine (PEI) and ethylene acrylic acid (EAA), offer significant advantages in sustainable packaging design by chemically modifying the surface of the substrate to enhance adhesion.

This study discusses adhesion issues in three case studies involving sustainable packaging materials: (1) extrusion coating of polyvinyl alcohol (PVOH) on paper; (2) extrusion lamination of paper and metallized film with starch biopolymer; and (3) extrusion coating of polyhydroxyalkanoates (PHA) on paper. These cases represent three adhesion challenges related to sustainable materials: fast crystallization rate, low processing

Other Research and Content Appearing in *TAPPI Journal's* June and July Issues

NONWOOD PULPING (June)
Conversion of paper-grade pulp from rice straw into dissolving pulp
Sharmin Islam, M. Mostafizur Rahman, M. Nakib Hossen, M. Nur Alam Likhon, Hasan Jameel, and M. Sarwar Jahan

FEATURE: FLEXIBLE PACKAGING CONFERENCE (July)
19th European PLACE Conference highlights challenges of balancing sustainability with product protection
Peter A. Gellerich

temperature, and secondary crystallization. Researchers used a three-step adhesion improvement procedure to identify the proper primer in each case study. This procedure included a wetting-out test with primer, an adhesion test, and an extrusion test with priming.

In the results, strong fiber tearing or destructive bonds were achieved in each case with the help of water-based primers. The results demonstrate the value of water-based primers in enabling the transition to more sustainable packaging structures without compromising performance. **360**

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Celebrating 110 Years of Innovation and Excellence

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Thank you for being part of our journey. Here's to what's next.