

LITERATURE REVIEW: USING RECYCLED PLASTICS FOR COMPOUNDING AND ADDITIVES

New End Market Opportunities (NEMO) for Film

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INTRODUCTION

Recycled plastics are a valuable resource and feedstock for manufacturing. Some plastics, like bottles, will be recycled back into similar applications, but often, recycled plastics are used for entirely different products than their initial application. Just like virgin plastics, recycled materials have many desirable attributes, which can be used to improve properties of other plastics and non-plastic materials. The plastics industry is committed to furthering new uses for recycled plastics, which requires innovative thinking about how, and where we use recycled materials.

This document consolidates prior research and news coverage of new and non-traditional uses for recycled plastics. The Plastics Industry Association (PLASTICS) hopes the information contained in this literature review will inspire innovation and new opportunities for all streams of recycled plastics.

Special thanks to the PLASTICS New End Market Opportunities (NEMO) for film workgroup for commissioning this document and making it freely available.

Scholarly Articles

Article Title	Product application	Recycled plastics used	Percentage of recycled materials used	Benefits	Challenges
System for making synthetic wood products from recycled materials	Building blocks	LDPE, HDPE	15% plastic material	Uses waste wood fiber and recycled plastics instead of virgin wood	
Economic and Environmental Comparison of Post-Consumer Recycled Polyethylene and Virgin Polyethylene Trash Bags	Trash bags	PE			
Development of new lubricating grease formulations using recycled LDPE as rheology modifier additive	Lubricating greases	LDPE			
Potential of using recycled low-density polyethylene in wood composites board	Wood boards	LDPE	50%	Reduce wood consumption and increase strength of wood boards	
Valorisation of waste plastic bags in cement-mortar composites as coating of local sand aggregates: physicomechanical characterization and potential uses	Cement	LDPE	8-12%	Reduces waste of plastic bags, reduced water absorption ratio by 90% and decreased density by 11.6%	
LDPE/EPDM Multilayer Films Containing Recycled LDPE for Greenhouse Applications	Greenhouse films	LDPE	25 - 50%	Using recycled LDPE reduces cost	Addition of EPDM necessary to reduce effect of weathering on LDPE only film. EPDM film retained 75-95% original extensibility after 9 months of weathering



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Experimental tests and technical characteristics of regenerated films from agricultural plastics	Agricultural plastic films	LDPE, HDPE		Doesn't require any additives in the blends	
Polyethylene and biodegradable mulches for agricultural applications: a review	Biodegradable mulch, agricultural mulch film	PE		more efficient use of soil nutrients, reduction of insect pests, moisture conservation, higher crop yield	breakdown of mulch sometimes unpredictable, more research needed
Novel recycled polyethylene/ground tire rubber/bitumen blends for use in roofing applications: Thermo-mechanical properties	Roofing and waterproofing applications	PE		Use of recycled PE increases material elastic and viscous properties at high temperatures	GTR (ground tire rubber) required to improve material behavior at low temperatures
Tightening the loop on the circular economy: Coupled distributed recycling and manufacturing with recyclebot and RepRap 3-D printing	3-D Printing filament	PE (ABS?)		Use of recycled materials reduces embodied energy by half and reduces cost of final consumer product	
Method for producing a supply obtained from the recycling of plastic material of industrial and post-consumer residues, to be used by 3-D printers	3-D Printing filament	PET, PA	Up to 100%	Recycled 3-D printer filament can be used for commercial and home use	Source is patent claim - not in production yet
Recycling in buildings: an LCA case study of a thermal insulation panel made of polyester fiber, recycled from post-consumer PET bottles	Thermal insulation	PET	100%	Saves more energy than thermal insulation panels made with virgin PET	
The effect of post-consumer PET particles on the performance of flexible polyurethane foams	Flexible foams	PET		Tensile resistance, strain at break, and tear resistance improved with use of post-consumer PET, as did compression set, compression resistance, and wear	



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Valorization of post-consumer waste plastic in cementitious concrete composites	Concrete composite	PET	<50%	Addition of post-consumer PET doesn't affect compressive strength or flexural strength of concrete composites and would save energy	
Composite material from fly ash and post-consumer PET	Concrete composite	PET	>50%	Fly ash was found to improve the use of post-consumer PET in composites - reduces thermal decomposition of PET, expedites melting & mixing of PET, reduces shrinkage of PET during molding process, increases compressive strength	
Potential applications of 3-D printing in the recycling of fishing nets & ropes	3-D Printing filament	RPFs: PLA, ABS, HIPS, PVA, PET, PA, PC	100%	Conclusion was that more research was needed, but has potential to reduce waste in small fishing communities	Limited success - contaminants compromised materials and caused damage to printer nozzles. More research needed
Thermal insulation enhancement in concretes by adding waste PET and rubber pieces	Concrete composite	PET		Addition of PET bottle pieces improves thermal insulation and reduces heat loss	
Recycling of PET bottles as fine aggregate in concrete	Concrete composite	PET	5%	used un-washed PET bottles (WPET) and was found to have similar workability characteristics, compressive strength, a moderately higher ductility and only a slightly lower tensile strength	
Characteristics of mortar and concrete containing fine aggregate manufactured from recycled waste polyethylene terephthalate bottles	Concrete composite	PET, WPLA	25%	Did multiple tests on amount of WPLA (25, 50, 75%), 25% was found to have the best structural efficiency	



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Recycled milk pouch and virgin LDPE-LLDPE-based jute fiber composites	Jute fiber composites	LLDPE, LDPE	100%	50/50 blend of virgin and recycled LDPE/LLDPE performed much better than 100% recycled jute fiber composite	100% recycled jute fiber has worse mechanical properties and poorer thermal stability compared to virgin polymer/jute fiber composites
Blending LLDPE and Ground Rubber Tires	Polymer blend	LLDPE			
Mechanical Properties and Crystallization Behavior of PP/Wood Flour Composites	Polymer blend	PP		Increased tensile strength when PP added	
Study on Modified PE for Wood Fiber-Plastic Composite Manufacture	Wood composite	LLDPE		LLDPE with maleic anhydride was studied for use in a wood fiber-plastic composite	
Structure and properties of compatibilized recycled poly(ethylene terephthalate)/linear low density polyethylene blends	Polymer blend	LLDPE, PET		Tensile properties improved, elongation at break and charpy impact strengths increased with addition of SEBS/SEBS-g-MA	
Study of recycled polyethylene materials as asphalt modifiers	Asphalt	LDPE		LDPE w/ lower molecular weight and wider molecular weight distribution was found suitable for asphalt modification	
The theoretic analysis and experimental study on PE modified asphalt	Asphalt	LDPE		Found that LDPE modified asphalt increases high-temperature stability and may improve aging performance	
Utilization of waste plastic in asphaltting of roads	Asphalt	LDPE	30%	Found that LDPE modified asphalt has better binding property, stability, density, and is more resistant to water	
Research of mixed-waste plastics from urban waste as road bitumen modifier	Asphalt	LDPE, HDPE, PP			



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Wood flour-reinforced plastic composites: A review	Polymer blend	HDPE, LDPE, LLDPE, PP		Wood flour reinforced plastic has improved mechanical, chemical, and thermal properties	
Evaluation of corn husk fibers reinforced recycled low-density polyethylene composites	Polymer blend	LDPE		Studied characteristics of LDPE and corn husk fiber blend for packing applications, found positive results	
3DPro-Development of low cost prosthetics using 3D printing technologies	3D Printed Prosthetics	PE		Unsure of how relevant this paper was but it's the only thing I've found of its kind - looks at 3D printing of prosthetics in 3rd world countries with recycled plastic	
LLDPE/PP Blends in tubular film extrusion: Recycling of mixed films	Polymer blend	LLDPE	85%	Studied mechanical properties of 85/15 LLDPE/PP mixture, found positive results for tear and impact strength	
Recycled plastic used in concrete paver block	Concrete Paver	PET, PP	10%, 20%, 30%	Would reduce overall waste if concrete aggregates could be replaced with recycled plastic	
Strength and behavior of concrete contains waste plastic	Concrete composite	PE	1%, 3%, 5%		Compressive, tensile, and flexural strength of concrete declined as amount of plastic increased in the mixture
Recycling of polyethylene films used in greenhouses - Development of multilayer plastic films	Multilayer plastic films	PE, LLDPE		Experiment found success in using multilayered film (with bottom layer composed of PE waste) as greenhouse films	
Production of recycled plastic aggregates and its utilization in concrete	Concrete composite	recycled plastic aggregate		Aggregate was lightweight, comparable density and strengths to other aggregates	
Blown film extrusion of post-consumer recycled LLDPE film	Plastic film	LLDPE		Blown film made of mix of post-consumer and virgin LLDPE. Tested for dart drop impact strength, cross and machine direction tear strength, and gauge uniformity	



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Characteristics of starch-filled LLDPE plastic processed from plastic waste	Plastic composite	LLDPE		Study contrasted virgin LLDPE with rice starch added and recycled LLDPE with rice starch. Virgin LLDPE with rice starch added increased melt flow index of LLDPE but MFI decreased with recycled LLDPE.	
Recycle of waste LDPE/PA6/LLDPE Composite film	Composite film	LDPE, LLDPE		Tested waste air bag with LDPE/PA6/LLDPE base material with LDPE-g-MAH as compatibilizer. Mechanical properties improved in blend as well as barrier properties	
Tensile properties of linear low density polyethylene (LLDPE) / recycled acrylonitrile butadiene rubber (NBRr) / rice husk powder (RHP) composites	Plastic composite	LLDPE		Tensile strength of composite decreased with increase of NBRr but elongation at break increased. Tensile strength & elongation at break for composites with ENR-50 increased.	
Rheological properties of RLDPE/LLDPE blends	Plastic composite	LDPE, LLDPE	100%	Blends of recycled and virgin LDPE & LLDPE showed potential successes	
Improved mechanical properties of recycled linear low-density polyethylene composites filled with date palm wood powder	Plastic composite	LLDPE		Adding date palm wood powder to recycled LLDPE increased flexural strength of composites by 1.5 times. Water uptake was partially suppressed with addition of powder	
Use of coir-filled LLDPE as a reinforcement for natural rubber composite	Rubber composite	LLDPE		Coir and LLDPE mixture had better compatibility with natural rubber than just the unmodified coir. Modified coir also showed greater storage modulus and lower tan delta	
Mechanical, thermal and morphological characterization of recycled LDPE/corn starch blends	Plastic composite	LDPE		Recycled LDPE/corn starch blend reduced MFI values, tensile strength, and elongation at break but increased modulus	



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Low-density polyethylene waste/recycled wood composites	Plastic composite	LDPE		LDPE from packaging film mixed with pine wood waste (PWW) and maleic anhydride grafted polyethylene. PWW amount can be adjusted to get different mechanical properties for different applications	
Flat-pressed wood plastic composites from sawdust and recycled polyethylene terephthalate: Physical and mechanical properties	Plastic composite	PET		Wood plastic composite's density, moisture content, water absorption, thickness swelling, and mechanical properties measured. Density decreased when sawdust content increased. Water absorption and thickness swelling increased when PET content decreased	
Characterization of wood plastic composites manufactured from recycled plastic blends	Plastic composite	LDPE		Used samples of construction plastic waste and municipal mixed plastic waste and tested for flexural, tensile, and un-notched impact strength, hardness properties, and water absorption. Found samples had lower strength, comparable hardness, and higher stiffness than virgin LDPE	
Rice husk filled polymer composites	Plastic composite	LDPE, HDPE, PLA, PP, PVC		Rice husk (RH) added to polymer composites increases biodegradability, toughness, resistance to weathering, makes the composites cheaper and more light weight. Gives composite a higher resistance to termite and ability to deal with moisture compared to wood based composites	
Effect of recycled materials on the properties of wood fiber-polyethylene composites - Part 2	Plastic composite	LDPE, LLDPE, PP		Contact angles increased with addition of Epolene E-43, then decreased as concentrations of urea formaldehyde (UF), phenol formaldehyde (PF), and isocyanate (ISO) increased. Contact angle ratings for different plastic types followed the sequences of PP > LLDPE > LDPE and distilled water > UF > PF > ISO	



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Properties of recycled LDPE/Birch fibre composites	Plastic composite	LDPE		LDPE reinforced with yellow birch fibre was put through simulation of recycling. Results showed polymer crystallinity increased with number of composite regeneration while zero-shear viscosity decreased with recycling	
The effects of bamboo powder on some mechanical properties of recycled low-density polyethylene (RLDPE) composites	Plastic composite	LDPE		LDPE mixed with bamboo powder (BP) had a decreased water sorption level, increased flame retardancy, and slight increase in the specific gravity of the composites. Tensile strength and elongation at break decreased with increased filler loading for composites	
Utilization of maize husk/recycled low density polyethylene waste materials for composite board production	Plastic composite	LDPE		Study found that adding maize husk to RLDPE improved compressive strength of the composite. Thermogravimetric analysis gave a max decomposition temp of 463C	
Chitosan filled recycled low-density polyethylene composite: Melt flow behavior and thermal degradation properties	Plastic composite	LDPE		LDPE mixed with chitosan and coupling agent ultraplus TP01. Melt flow index values decreased with increasing chitosan but increased with rise of temp. When Ultraplus TP01 was added, MFI values decreased. Thermal stability was reduced with increase of chitosan but increased with addition of ultraplus TP01	
Valorization of recycled LDPE by MMT Nanocomposite	Plastic composite	LDPE		LDPE reinforced with nanoclay montmorillonite (MMT) had increased mechanical strength, thermal stability, and sorption, especially for recycled matrix. Recycled composites presented 15% eco-efficiency increase in comparison to virgin composites	



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The impact of recycled raw materials on the properties of wood-plastic composites	Plastic composite	LDPE		Studied various wood-plastic composites and found improvements in moisture resistance and impact strength and decreased price in various composites	
Effects of recycled materials on the properties of wood fiber-polyethylene composites - part 2	Plastic composite	LDPE, LLDPE, PP		Study looked at effects of a compatibilizer on the wettability of birch plywood and polyolefins. Found contact angles increased with addition of Epolene E-43 and decreased as concentrations increased for urea formaldehyde (UF), phenol formaldehyde (PF), and isocyanate (ISO).	
Recycling of polyethylene into strong and tough earth-based composite building materials	Building blocks	PE	0-30%	PE waste used as reinforcement in laterite bricks. Composite with 20 vol % of PE had best combination of flexural/compressive strength and fracture toughness	
Effects of reinforcement loading on physical and mechanical properties of developed recycling low density polyethylene/maize cob ash particulate (PLDP/MCAp) composite	Plastic composite	LDPE	75-80%	Physical and mechanical properties such as hardness values, density, young's modulus, flexural strength and impact energy increase with a maize cob ash particulate up to 20-25 wt % MCAp then decrease	
Strength and sorption properties of bamboo (bambusa vulgaris) wood-plastic composites	Plastic composite	LDPE		Tested three levels of plastic/fibre mixing ratios (1:1, 2:1, 3:1). Results found that as plastic/fibre mixing ratio and board density increased the tensile strength, MOE and MOR increased and TS and WA decreased	



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Mechanical properties of chemically treated sawdust-reinforced recycled polyethylene composites	Plastic composite	PE		Sawdust treated with cetyltrimethylammonium bromide (CTAB) was used to reinforce recycled PE composites. Treated composites had higher tensile strength and improved young's modulus, flexural strength, flexural modulus, and hardness values compared to untreated composites	
Tensile properties of glass fibre reinforced recycled mixed plastic composites	Plastic composite	HDPE, LDPE, PP	70-90 wt %	Recycled HDPE, LDPE, and PP were blended and reinforced with short glass fibre at 10-30 wt%. Tensile strength and modulus increased with glass fibre but composite became brittle and ductility was reduced	
Recycling of plastic solid waste: A state of art review and future applications	Plastic composite	HDPE, LDPE		Paper reviews recycling processes and blending virgin and recycled HDPE/LDPE/Nylon PSW with various reinforcements such as sand, natural fibers, hemp fibers, and metal powder	
Fabricating and tensile characteristics of recycled composite materials	Plastic composite	HDPE, LDPE, PP	20% LDPE, 4% HDPE, 25% PP (one example)	Composite blend indicated to the left had improved tensile stress	
Mechanical properties: wood lumber versus plastic lumber and thermoplastic composites	Plastic composite	HDPE, LDPE, PP, ABS		Study compares modulus of elasticity and the flexural, compressive, tensile, and shear strengths of plastic lumber and wood lumber	
Rheological and mechanical properties of composites made from wood flour and recycled LDPE/HDPE blend	Plastic composite	LDPE, HDPE		Studied composites of LDPE and HDPE with wood flour. Found that melt pre-mixing of recycled LDPE/HDPE improved mechanical properties of the wood-plastic composite	



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Physico-mechanical properties of recycled polyethylene composites reinforced with chemically treated sawdust	Plastic composite	LDPE, HDPE, PE	65-80%	Sample with sawdust treated with NaOH+Surfactant had better mechanical properties and greater resistance to water absorption. Recycled PE matrix-based composites had excellent durability and mechanical properties compared to virgin plastics	
Effect of elevated temperature on the tensile properties of recycled mixed plastic waste	Plastic composite	LDPE, HDPE, PP		Study found thermal stability of mixed recycled plastics similar to virgin plastics. Tensile strength and modulus reduced when temp increased from 23C to 100C. Higher reduction of tensile modulus than tensile strength at higher temp	
Utilization of rice husk as reinforcement in plastic composites fabrication - a review	Plastic composite	LDPE, PP		PP/Rice Husk (RH) composite had decreased stress at peak and increased tensile modulus and modulus in flexure. LDPE/RH composite had low strength, high stiffness, and high hardness	
Glass fibre and recycled mixed plastic wastes: recent developments and applications	Plastic composite	LDPE, HDPE, PVC, PET, PP		Composites with glass fibre added have high stiffness and strength and reduced ductility	
Effects of raw materials on the properties of wood fiber-polyethylene composites - Part 3: Effect of a compatibilizer and wood adhesive on the interfacial adhesion of wood/plastic composites	Wood plastic composite	LDPE, LLDPE, PP		ISO-bonded LDPE had highest interfacial shear strength compared to other LDPE composites. Addition of E-43 increased interfacial shear strength for all plastic except ISO-bonded LDPE and LLDPE. LDPE and LLDPE composites experienced adhesive failure and PP composites had cohesive failure	



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Comparative study of the morphology and properties of PP/LLDPE/wood powder and MAPP/LLDPE/wood powder polymer blend composites	Wood plastic composite	LLDPE, PP	90-70 wt %	MAPP/LLDPE had better mechanical and thermal properties than the PP/LLDPE blend because of a stronger interfacial interaction between MAPP, LLDPE, & wood powder (WP). MAPP/LLDPE blend was also more thermally stable than the PP/LLDPE blend	
Microfibrillar reinforced composites from PET/LDPE blends: Morphology and mechanical properties	Plastic composite	LDPE, PET	LDPE at 50 and 70 wt %	LDPE was reinforced by microfibrils of PET and found the elastic modulus 10x higher than plain LDPE and 3x higher than LDPE reinforced with glass spheres. Tensile strength at least 2x higher than plain LDPE or LDPE reinforced with glass spheres	
Composite of low-density polyethylene and aluminum obtained from the recycling of postconsumer aseptic packaging	Plastic composite	LDPE		Composite of LDPE and PEAL (aluminum composite) had higher thermooxidative stability, higher crystallinity, lower impact resistance, and higher tensile strength than other olefin polymers	
Silane-crosslinking of recycled low-density polyethylene/wood composites	Wood plastic composite	LDPE		Studied silane-crosslinking of recycled LDPE wood composites. Crosslinked composite strength, toughness, and creep resistance were improved compared to uncrosslinked composites. Flexural strength was doubled compared to uncrosslinked samples	
Influence of thermoplastic elastomers on adhesion in polyethylene-wood flour composites	Wood plastic composite	LDPE		rLDPE/wood flour mix had SEBS-MA added as compatibilizer. Tensile strength reached max at 4wt% SEBS-MA content. SEBS-MA improved impact strength and elongation at break but decreased stiffness	



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Influence of processing conditions on the tensile properties of unidirectional UHMWPE fibre/LDPE composites	Plastic composite	LDPE		Tensile strength decreased but tensile modulus was not strongly affected.	
Effect of ageing on the physical and mechanical properties of sisal-fiber-reinforced polyethylene composites	Plastic composite	LDPE		LDPE/sisal composites with and without addition of cardanol derivative of toluene diisocyanate (CTDIC). Composites treated with CTDIC showed superior mechanical properties and better dimensional stability compared to untreated composites	
Laboratory design and investigation of the properties of continuously graded asphaltic concrete containing recycled plastics aggregate replacement (Plastiphalt)	Concrete composite	LDPE		Study found the compacted Plastiphalt mix has lower bulk density than conventional control mix. A 30% aggregate replacement with LDPE reduces density by 16%. LDPE replacement also results in a 250% increase in the Marshall stability value and an improved Marshall quotient value.	
Short pineapple-leaf-fiber-reinforced low-density polyethylene composites	Plastic composite	LDPE		Composites of short pineapple-leaf-fiber (PALF) reinforced LDPE were made with melt-mixing and solution-mixing methods. Solution-mixed composites had better tensile properties than melt-mixed. Composite performed better than other cellulose-fiber-reinforced LDPE composites	
Properties of low-density polyethylene/palm kernel shell composites: Effect of polyethylene co-acrylic acid	Plastic composite	LDPE		Study found that increasing palm kernel shell (PKS) decreased tensile strength and elongation at break but Young's modulus and water absorption of composites increased	



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Performance of polyolefin composites containing recycled paper fibers	Plastic composite	LDPE, HDPE, PP	0-40 wt %	LDPE composite had better modulus of elasticity than both the HDPE and PP composites. Tensile strength decreased at higher filler content for HDPE and PP composites. The addition of newspaper fibers did not significantly affect the insulating properties of the composites	

News Articles

Article Title	Product application	Recycled plastics used	Percentage of recycled materials used	Benefits	Challenges
FDA approves post-consumer PP for reusable packaging	Reusable crates & pallets	LDPE, PP	100	Strict source control, low likelihood of contaminants in recycled PP/LDPE blend	
Can plastic roads help save the planet?	Asphalt	PE		Recycled plastic replaces bitumen as the binding agent in asphalt	
MIT students fortify concrete by adding recycled plastic	Concrete	polyethylene terephthalate	1.5%	Reducing CO2 emissions from concrete production by using recycled plastics. Also makes cement stronger	Requires additive of fly ash to produce a stronger concrete
Recycler rescues forage bags from landfills	Can liners	LDPE	100%	Diverts ag bags from landfill; Revolution Bags have a closed loop system	Requires washing ag bags
Closing the cycle of plastic: Decent housing solutions from recycled plastics	Plastic bricks	PP, LDPE, HDPE, PET, PS, HIPS, ABS, PC	100%	Water resistant, combustion resistant, durable, immune to insects/microorganisms, insulates well, economically competitive	



Article Title	Product application	Recycled plastics used	Percentage of recycled materials used	Benefits	Challenges
This Japanese invention can recycle plastic into oil	Oil/Fuel	PE, polystyrene (PS), polypropylene (PP)	100%	1kg of plastic can be converted into 1 liter of oil with 1 kWh of electricity, made for household use	Made for household use and end product is oil
One use for post-consumer plastic film: agricultural irrigation	Irrigation piping	LDPE	100%	Better than previously used metal because this does not corrode, is cheaper, doesn't have to be perfect in appearance	
100% Film made from post-consumer waste: A challenging application	Plastic film	LDPE	100%	Produces a good film once contaminants have been sorted out	Lots of contaminants, plastics must be washed first
From consumer to supplier: Trex has begun producing recycled LLDPE pellets for commercial sale	Drip irrigation tape, trash bins, blown film, trash bags, ag film, garden products, composite lumber	LLDPE	100%	Company already produces consistent, cost-effective LLDPE pellets, hoping to expand use for post-consumer plastics	
Post-consumer waste becomes high-quality film and Poligroup's new model plant	Plastic film	LDPE, LLDPE	100%	Uses ag LDPE film, LLDPE film from bale wrapping, and film from household waste. End product is high quality, thin film and is inexpensive to produce	Requires human sorting and washing step.
Ultra-Post Reusable T-Shirt Bags	Plastic bags	LDPE	20%	Is 100% recyclable	
Plastics that can be recycled for 3D printing	3-D Printing	LDPE	100%	Recycled LDPE resulted a more flexible plastic when 3D printed, could have different applications than traditional plastics used	The shredder was set up for PLA and PS, not LDPE, so there was more work on the front end to prepare the LDPE
Best recycling ever: turning old plastic bags into carbon nanotubes	Carbon nanotubes	LDPE, HDPE		The added catalyst (cobalt particles) makes the nanotubes suitable for use in lithium-air batteries, which is viewed as an asset	Had to add large amounts of catalyst for the process to work



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Composite decking leader repurposes its recycled plastic into polyethylene pellets	Plastic pellets	LLDPE		Ideal for use of: trash bags, bins, totes, kayaks. Uses Trex's leftover material from wood composite deck building	
Plastic Lumber Possibilities	Wood composite	PE, PP		More durable, stable, resilient, and resistant to weather, rot, mildew, and termites. Don't require repainting or restaining - are low maintenance	Viscoelasticity is main limitation. Time and temperature can cause "creeping" or permanent deformation over time
Roads made of plastic waste in India? Yes! Meet the professor who pioneered the technique	Cement additive, plastic brick (plastone)	LDPE, PE		Reduces plastic waste and bitumen use for paving roads. Process requires no new machinery. Increases durability of roads	
You can make concrete 20% stronger by adding recycled plastic in & also save the environment	Concrete composite	PE		Recycled plastic treated with gamma radiation made cement 20% stronger than normal with no negative side effects	
In with recycled plastic bricks, out with cement	polymer concrete bricks	PE		Polymer concrete absorbs less water so is better for freezing temperatures, is also less expensive to create than traditional bricks	
Old plastic bags become bricks in Indian houses	Plastic bricks	Soft plastic - plastic bags and foil-covered snack bags	100%	Bricks can withstand up to 6 tons of pressure and very durable. Can withstand monsoon season and the creator is working on a way to create bricks without electricity so that rural areas can create them	
Plastic bags as building blocks	Plastic bricks	Plastic bags	100%	Easy to create, requires no additives, and is cost-effective when compared to cement or ordinary bricks.	



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This neighborhood recycling lab turns plastic into building blocks to make the neighborhood better	Plastic bricks	Plastic bags	100%	Increases recycling, decreases waste, educates the public, produces a durable brick	
Bricks from recycled plastic	Plastic bricks	PET	100%	Structurally sound enough to withstand earthquakes and typhoons, relatively cheap, and sustainable	
ByFusion: Creating the building blocks for tackling ocean waste	Plastic bricks	All plastic except polystyrene	100%	Structurally sound, cheap to create, uses a wide variety of plastic, uses a non-toxic manufacturing process	
JCU Team wins innovation award for 'green' concrete	Concrete composite	PP		LCA shows production with recycled plastic produces 90% less CO2 than using steel mesh in concrete and plastic fibers are equivalent in strength	
Plastic and UAE Sand are building block of new brick	Plastic bricks	Plastic waste	30%	Uses unsorted and uncleaned plastic waste. Is resistant to oils, acid, salts and alkalis. Is 30% lighter than concrete, insulates against heat & cold, is flame-resistant and water-resistant. It costs 50% less to manufacture than concrete	
Kiwi company turns plastic waste into high-quality concrete	Concrete composite	Plastic waste		Don't need to clean the plastic. End product is 10-40% lighter than plain concrete, would save on transportation costs.	
Sustainable building materials for low-cost housing	Plastic bricks	Polypropylene		Bricks made of polypropylene and rice husks. Bricks are fire resistant, provide heat and sound insulation, are waterproof and lightweight.	



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Lightweight plastic panels manufactured from recycled plastics - panels for commercial vehicles and other applications	Plastic panels	PP, PET, PE, LDPE		Panels are much lighter, will save fuel costs and reduce co2 emissions in transportation. Has applications in insulation, acoustic and impact resistance, caravans, portable cabins, staging, decking, and flooring.	
High strength wood plastic composites recycled from construction and demolition wood waste	Plastic composite	PE, PP		Company evaluated recycled wood plastic composite boards	

Additional HDPE Applications

Article Type	Article Title	Product application	Recycled plastics used	Percentage of recycled materials used	Benefits	Challenges
Scholarly	Use of post-consumer waste plastics in cement-based composites	Cement	HDPE	0-5%	Increased performance of concrete's compressive strengths	Low percentage recycled material
Scholarly	Diversion from landfill: quality products from valuable plastics	blow-molded bottle	HDPE	100%	Properties of 100% post-consumer HDPE exceeded materials specifications for virgin plastic designs	



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Scholarly	Performance of Corrugated HDPE Pipes Manufactured with Recycled Content 1 Underneath Commuter Railroads	Corrugated drainage pipe	HDPE			
Scholarly	Development of a recycled polymer modified binder for use in stone mastic asphalt	Asphalt	HDPE	4%	Out-performs traditional binders in stone mastic asphalt	Low percentage plastic
Scholarly	Suitability of recycled HDPE for 3D printing filament	3-D Printing filament	HDPE	100%	Found it comparable to ABS and PLA	
Scholarly	Plastic container made from a fusion blend of post-consumer plastic and ethylene polymers	Plastic container	HDPE	25 - 95%	Better crack resistance than usual when working with post-consumer resins	Blend of virgin and recycled HDPE and virgin LDPE
Scholarly	Life cycle analysis of distributed recycling of post-consumer high density polyethylene for 3-D printing filament	3-D Printing filament	HDPE	100%	Recycling & 3-D printing method for low-density population centers or at home	
Scholarly	Feasibility study of use of recycled high-density polyethylene and multi response optimization of injection molding parameters using combined grey relational and principal component analyses	Trays	HDPE	100%	Tensile, compressive, and flexural strengths of recycled HDPE are very close to virgin HDPE - is a good substitute	
Scholarly	Dimensional stability and mechanical behavior of wood-plastic composites based on recycled and virgin high-density polyethylene	Wood plastic composites	HDPE		recycled HDPE had equivalent tensile and flexural properties as virgin HDPE and, when added to wood, improved stability and strength	Requires maleated polypropylene at 3-5% to help with stability and mechanical properties



Article Type	Article Title	Product application	Recycled plastics used	Percentage of recycled materials used	Benefits	Challenges
News	PE Recycled Fix-Corp to Begin Making Pallets	Plastic pallets	HDPE	100%	Uses recycled HDPE from their own recycling plant, already has infrastructure in place	
News	Study: Pipe with recycled HDPE good for rail uses	Corrugated drainage pipe	HDPE	49%	Study showed no discernible differences in performance of the recycled HDPE pipe vs the virgin HDPE pipe after 3 years	
Scholarly	Correlation of rheological and mechanical properties for blends of recycled HDPE and virgin polyolefins	polymer blend	HDPE		Studied rheological and mechanical properties for different blends of recycled HDPE and virgin polyolefins	
Scholarly	Study on mechanical properties of recycled HDPE/Waste rubber powder blends	polymer blend	HDPE	80%	When blend was at 80% recycled HDPE and 20% waste rubber powder it had the best mechanical properties	
Scholarly	A review on tertiary recycling of high-density polyethylene to fuel	Fuel	HDPE	100%		
Scholarly	Characteristics of wood-fiber plastic composites made of recycled materials	Wood fiber composite	HDPE		Composites with recycled HDPE had superior properties	
News	Large scale HDPE recycling trial	Plastic milk bottles	HDPE	30%	Recycled HDPE performs exactly the same as virgin HDPE, meaning no new equipment is required except blending equipment	
News	Study shows strength of HDPE pipe with recycled resin	Corrugated pipe	HDPE	49%	Pipe with 49% recycled HDPE performed exactly the same as pipe with 100% virgin material installed at same time and had same expected lifetime of 100+ years	
News	Porous Paving System	Pavers	HDPE	100%	Pavers have long-term durability	
News	Letting the rain fall through	Pavers	HDPE		Pavers are durable and can withstand consistent traffic, abrupt braking/acceleration, and slightly sloped surfaces	



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News	Cornfield tiled and planted in one day	Corrugated pipe	HDPE	50%+	Has long service life and is resistant to cracking. HDPE is a versatile material and can be created into any perforation pattern without diminishing performance or longevity. Is also more resistant to frost than concrete pipes	
News	Indian company Protoprint transforms waste into 3D printing filament for commercial use	3-D Printing filament	HDPE	100%	Reduces waste and increases local work without compromising filament	
News	3D Printing a solution to the major waste disposal crisis in Samoa	3-D Printing filament	HDPE	100%	Reduces waste without compromising filament	
Scholarly	Mechanical and morphological properties of recycled high-density polyethylene, filled with calcium carbonate and fly ash	Plastic composite	HDPE		HDPE/calcium carbonate/fly ash mixture had improved mechanical properties	
News	Got Milk? Then you've got 3D printer filament at a 99.7% discount	3-D Printing filament	HDPE	100%		
Scholarly	Mobile open-source solar-powered 3-D printers for distributed manufacturing in off grid communities	3-D Printing filament	HDPE	100%	Analyzes RepRap technology and rural applications	
Scholarly	Mechanical properties of wood-plastic composite (WPC) made of recycled high-density polyethylene (HDPE) and recycled wood flour (RWF)	Plastic composite	HDPE		Looks at mechanical properties of HDPE and recycled wood flour composite	



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Scholarly	The impact of plastics virginity on water absorption and thickness swelling of wood plastic composites	Plastic composite	HDPE, PP	50%, 75%	Compared adding wood flour to HDPE & PP in different weights. Water absorption and thickness swelling of composites with PP was lower than with HDPE. Composite with 50% wood flour and 50% HDPE had maximum moisture sorption	
Scholarly	Properties of wood plastic composites made of recycled HDPE and wood flour from CCA-treated wood removed from service	Plastic composite	HDPE	50%	HDPE and CCA-treated wood samples had higher flexural bending properties compared to composites with virgin pine or recycled urea formaldehyde bonded particleboard. Composite also had higher modulus of elasticity and modulus of rupture	
Scholarly	Development of recycled plastic composites from consumer electronic appliances	Plastic composite	HDPE, ABS, PS, PC		PC-ABS-HDPE blend had highest modulus value and withstood most stress and strain of any other composite tested.	
Scholarly	Outstanding impact resistance of post-consumer HDPE/multilayer packaging composites	Plastic composite	HDPE		Blend of HDPE, PET, PE, and aluminum was found to have higher tensile impact strength and elasticity compared to pure polyethylene	
Scholarly	Dynamic mechanical and thermal properties of MAPE treated jute/HDPE composites	Plastic composite	HDPE		Tensile, flexural, and impact strengths increased with the increase in jute fibre content up to 30% - higher than that caused a deterioration in mechanical strength. Composites treated with MAPE showed improved properties vs. untreated composite	
Scholarly	Effect of nanographene on physical, mechanical, and thermal properties and morphology of nanocomposite made of recycled high-density polyethylene and wood flour	Plastic composite	HDPE	70%	Study found that by increasing nanographene up to 0.5% by weight, flexural strength, flexural modulus, and notched impact strength of composite increased. At 2.5 wt% nanographene these properties reduced.	



Article Type	Article Title	Product application	Recycled plastics used	Percentage of recycled materials used	Benefits	Challenges
Scholarly	Study of wood-plastic composites with reused high-density polyethylene and wood sawdust	Plastic composite	HDPE		HDPE/sawdust composite had low plastic strain and improved mechanical responses including modulus and maximum stress	
Scholarly	Preparation and properties of wood plastic composites made of recycled high-density polyethylene	Plastic composite	HDPE	15, 30, and 45 wt%	Study found addition of polyethylene-grafted maleic anhydride (PE-g-MA) improved compatibility between recycled HDPE and poplar fibers. PE-g-MA also improved stability and mechanical properties and tensile strength.	
Scholarly	Extruded bagasse fiber plastic composites: creep performance	Plastic composite	HDPE, PVC		HDPE/bagasse composites creep more compared to PVC and PP composites	
Scholarly	Fly ash in optimized composites based on recycled plastics and rubber	Plastic composite	HDPE, PET	35 wt% HDPE, 5 wt% PET	0.25 wt% fly ash addition to the composites increased compression resistance by 3x. Composites with fly ash also have non-wetting behavior and dense surface structure	
Scholarly	Development of wood flour-recycled polymer composite panels as building materials	Plastic composite	HDPE, PP		rHDPE and rPP mixed with sawdust and HDPE and PP mixed with sawdust were tested. Recycled composites had excellent dimensional stability & mechanical properties compared to virgin samples	
Scholarly	Rheological properties of HDPE/chitosan composites modified with PE-g-MA	Plastic composite	HDPE		Presence of chitosan increases complex viscosity, loss modulus, storage modulus and torque. PE-g-MA increased matrix-filler interactions and acted as an effective compatibilizer	
	A mechanical analysis on recycled PET/HDPE composites	Plastic composite	HDPE, PET		Studied the stiffness and machinability of PET/HDPE blend, found good performance for compression and machinability	



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	Mechanical properties of composites from sawdust and recycled plastics	Plastic composite	HDPE, PP		Studied mechanical properties of wood plastic composites made from virgin and recycled HDPE or PP and sawdust. Composites with PP had higher stiffness and strength than HDPE composites but lower unnotched impact strength. Mechanical properties of composites with recycled plastics were comparable to ones with virgin plastic	