RNG Plastics®
Renewable Fossil Fuel Plastics
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Micro- and Nano-Contaminants: The Unaddressed Risk in Recycled Plastics – Why Zero Contamination via RNG Plastics Is the Only Defensible Standard

A White Paper - March 2026

Executive Summary

Mechanical recycling of plastics is promoted as a cornerstone of the circular economy, yet it systematically generates and concentrates microplastics (MPs, <5 mm) and nanoplastics (NPs, <1 µm)—collectively MNPs—that standard cleaning processes cannot remove. Regulatory thresholds focus on macro-level "acceptable" contamination (e.g., <0.1–5% by weight or trace ppb/ppm migration), ignoring the exponential accumulation of these invisible particles over 1–3 recycling cycles. Recent peer-reviewed research confirms MNPs penetrate human tissues, trigger chronic inflammation and oxidative stress, and are linked to elevated risks of cardiovascular disease, cancer, neurological disorders, reproductive harm, and more.

Recyclers and many standards avoid addressing nano-scale contaminants because detection is technically challenging and removal is economically unviable (advanced methods cost 5–10× virgin resin). RNG Plastics offers the only truly zero-contamination pathway: a landfill-safe, EPA-aligned technology that can bypass mechanical recycling entirely. Engineered Enhanced Polymeric Structure (EPS) resins remain inert during product use and storage, then enable safe methane capture in regulated landfills—producing upcycled renewable natural gas (RNG) identical to the original plastic feedstock—while leaving no residual MNPs.

RNG Plastics Are in Alignment with Zero-Contamination Goals Products incorporating RNG Plastics' technology for EPA-regulated landfills—rather than mechanical recycling—avoid the accumulation of nano- and micro-contaminants inherent in recycling streams. Mainstream science confirms that recycled plastics invariably retain or acquire such particles, amplifying health risks, whereas controlled landfill management can mitigate environmental release per established protocols. This white paper details the science, regulatory gaps, health evidence, and RNG solution for decision-makers seeking defensible, health-protective sustainability strategies.

1. Regulatory Standards Define "Acceptable" Contamination – But Not Zero Risk

Regulatory bodies base limits on short-term toxicological models, not chronic nano-scale accumulation:

- **FDA (21 CFR 174–179)**: Allows <0.5 ppb migration for non-carcinogens and <0.1 ppm for heavy metals in food-contact recycled PE. RNG Plastics' EPS resins pass REACH migration tests with no flagged residues.
- **APR Critical Guidance Protocol**: Tolerates <1% additive residues and <5% total impurities in PCR bales, but addresses only macro properties—nano/micro particles are unmonitored.

Its guidelines allow for higher "acceptable" contamination levels than the stricter health-based thresholds of the EU Packaging and Packaging Waste Regulation (PPWR), and evidence suggests this discrepancy manifests after just one recycling cycle.

- **EU REACH & PPWR (2025 updates)**: Requires <0.1% unintentional substances (e.g., phthalates) and mandatory microplastics reporting. Migration limits (<10 mg/dm^2 per EN 10/2011) are met by RNG materials, yet post-2–3 cycles studies show 5–20 ppm organic/inorganic buildup.
- **EPA LMOP**: No PCR rules, focuses on engineered landfills for 70–95% methane capture efficiency in anaerobic phases III–IV (5–30 years post-placement). RNG Plastics is explicitly compatible.

In practice, “acceptable” often means 1–5% total contaminants by weight. Health scientists (WHO, Endocrine Society) and recent reviews argue this underestimates cumulative nano-exposure. A 2024 global estimate projects mechanical recycling alone will discharge 0.749 Mt of microplastics by 2060—rising even as other sources decline.

2. The Micro- and Nano-Contamination Crisis That Recyclers Avoid

Mechanical recycling (shredding, washing, extrusion) is a primary generator of MNPs. Crushing tests show waste plastics release far more particles than virgin material due to labels, adhesives, and prior degradation. Airborne emissions during shredding reach 22,000–1,300,000 particles/cm^3 in the 10–420 nm range—3 to 2,910× background levels.

Each cycle introduces new contaminants (inks, cross-stream residues) while fragmenting existing plastics into smaller, more bioavailable particles. After 1–3 cycles, nano-particle counts can reach 10^4–10^5 per gram and continue doubling. Standard washing misses <100 nm particles; even supercritical CO_2 extraction achieves only 90–95% removal at prohibitive cost.

Recyclers avoid the micro- and nano-issues because:

- Current standards (APR, ISO) focus on macro impurities.
- Detection of true nanoplastics requires advanced spectroscopy/electron microscopy not routine in sorting facilities.
- Acknowledging the problem would undermine the “recycled content” marketing narrative and require costly process overhauls.

Result: Recycled resins increasingly carry a hidden MNP burden unsuitable for food-contact, medical, or high-safety applications.

3. Documented Human Health Implications

Emerging evidence links MNPs to systemic toxicity via ingestion, inhalation, and dermal routes. Particles cross biological barriers, accumulate in tissues, and act as vectors for additives (BPA, phthalates, heavy metals) and pathogens.

Key findings from 2023–2025 research:

- **Cardiovascular**: 2024 NEJM study of 304 carotid endarterectomy patients found polyethylene in 58.4% and PVC in 12.1% of plaques. Patients with MNPs showed markedly higher inflammation (elevated IL-6, TNF-α, etc.) and a **4.53-fold increased risk** (HR 4.53, 95% CI 2.00–10.27) of myocardial infarction, stroke, or death over ~34 months.
- **Neurological & Metabolic**: MNPs induce oxidative stress, mitochondrial dysfunction, and neuroinflammation—linked to Parkinson's, dementia, and metabolic disorders in human cell and animal models.
- **Reproductive & Developmental**: Particles detected in placentas, testes, semen, and breast milk; associated with reduced fertility, low birth weight, and impaired larval development in zebrafish (proxy for endocrine disruption).
- **Cancer & Inflammation**: Genotoxicity, cell death, and chronic inflammation pathways observed; MNPs found in lungs, livers, and atherosclerotic plaques.

A 2024 Science review after 20 years of research concludes MNPs are now "pervasive in the food we eat, the water we drink, and the air we breathe," detected throughout the human body, with calls for urgent risk assessment.

Zero contamination is the only defensible standard for health-conscious applications.

4. Why Mechanical Recycling Falls Short

- **Accumulation**: Contaminants persist or increase; phthalates >5 ppm after 2–3 cycles (Environmental Science & Technology studies).
- **Cleaning Limitations**: No scalable, economical technology removes all nano-particles.
- **Economic Reality**: Advanced purification costs 5–10× virgin resin; most facilities rely on basic washing.
- **Secondary Pollution**: Recycling itself emits MNPs into air, wastewater, and sludge.

5. The RNG Plastics Zero-Contamination Solution

RNG Plastics integrates a tiny amount of proprietary EPS (Enhanced Polymeric Structure) resin into standard PE, PET, PP, PVC, or NBR. The additive:

- Has no effect on mechanical properties, clarity, food safety, or performance during 5+ years of use/shelf/storage life.
- Is fully compatible with existing extrusion (stable to 550°F) and mechanically recyclable per APR/EU PPWR if desired.
- Activates only in EPA-regulated landfills during natural anaerobic phases III–IV (~5–30 years).

Mechanism (see FIG. A – Safe Methane Capture in EPA Landfills): Unlike bio-accelerators (premature aerobic degradation) or oxo-degradables (microplastic fragmentation), RNG Plastics remains stable until landfill conditions trigger controlled conversion. Giant wells create a warm biodigester environment; EPS resins enable the plastic + organics to produce methane, which is captured (70–95% efficiency per LMOP data) and upgraded to RNG—the identical feedstock for new virgin resins. Traditional plastics remain buried inertly. No uncaptured GHGs, no residual MNPs in future PCR streams, and zero contamination risk.

Certifications Available to the Supply Chain: Full FDA/REACH compliance, ASTM/LCA via Aropha & Intertek (ISO 17025), Prop 65, FTC Green Guides, EU 94/62/EC. SDS confirms "N/A" for intentional biodegradation.

Carbon & Economic Benefits: Supply-chain participants can claim verified carbon offsets/credits (Verra 2026 projections: $200–$400 per ton) while paying only ~2–3% premium—often offset by credits.

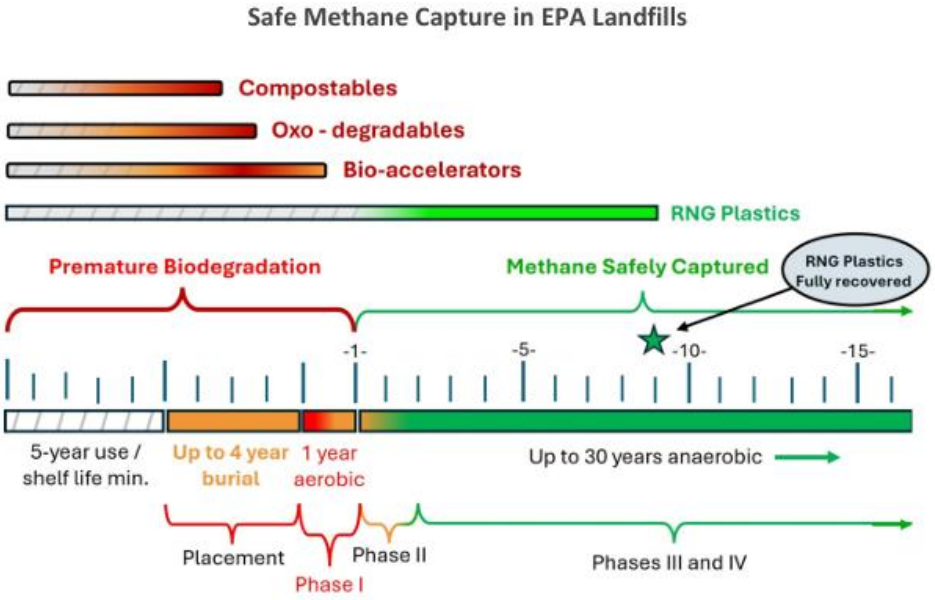
6. Conclusion

Mechanical recycling, while well-intentioned, cannot deliver true circularity when micro- and nano-contaminants accumulate unchecked and recyclers sidestep the issue. For applications where human health is paramount—food packaging, medical devices, consumer goods—**zero contamination is non-negotiable**.

RNG Plastics provides a scientifically engineered, EPA-supported, immediately scalable alternative: a landfill-circular model that protects health, captures renewable energy, and closes the loop without perpetuating MNP pollution.

Corporate leaders and engineering teams ready to move beyond incremental recycling improvements are invited to explore pilot programs, technical data packages, or IP licensing.

FIG. A



Compostables brands: Ingeo, BASF, hybrids, and all others.
Oxo – degradables: Smart (Eclipse), EPI, Symphony, and all others.
Bio-accelerators: EcoPure, Ecologic, enzymes, and all others.
RNG Plastics: RNG Plastics and Landfill-Safe.