

Fact Sheet

Biodegradable PHA Shotgun Wads

Researchers at the Virginia Institute of Marine Science, College of William & Mary have been working on solutions to plastic pollution affecting the marine environment. Plastic shotgun wads have become a common marine debris item collected during beach cleanups. “Wad” refers to a component of a shotgun shell that is used to separate the shot (pellets) from the powder. While the shotgun shell or casing is ejected near the shotgun and is easily retrieved, the wad is fired out of the barrel along with the pellets and is very difficult to recover (Fig 1). Hunters generally recover spent shells or casings but, due to the range of shotguns, there is no practical way to recover the spent non-degradable plastic shotgun wads.



Figure 1. High speed photography of standard plastic wad.

Spent plastic shotgun wads can present safety, nuisance, and environmental impacts in freshwater and estuarine waters (Fig. 2). When sportsmen hunt for waterfowl using shotguns, the plastic wads are lost into the adjoining water or marshland and can enter the food web as non-degradable plastic debris. The consumption of plastic compromises fitness and can harm aquatic species. Plastic wads have been found in the stomachs of ocean foraging birds, including albatross presumably due to their resemblance to squid, a common food item (Fig 3). Over time the spent plastic wads can fragment into smaller and smaller microplastic pieces. Microplastic fragments have become a significant marine debris concern worldwide. Once microplastics enter the aquatic environment, their buoyancy, size, and longevity within the water column can affect the food web. Studies have shown uptake of microplastics by worms, mussels, crabs, and fish^{1,2}. This is important because plastics can concentrate toxic pollutants which can be transferred up the food web.



Figure 2. Plastic shotgun wads from beach cleanups.

VIMS researchers are developing a completely biodegradable and sustainable shotgun wad that has the same functional characteristics of plastic wads but completely biodegrades*. The wad is made of polyhydroxyalkanoate (PHA) which is naturally produced by bacteria and is already present in aquatic environments. Bacteria produce PHA as a small granule to store energy, similar to humans storing energy as fat. When PHA comes into contact with aquatic environments, the resident bacteria recognize PHA as a food source and consume it. PHA meets the American Society of Testing and Materials certification as biodegradable in aquatic environments, European Standards and Vincotte International certification for biodegradation³, as well as the US Food and Drug Administration standards for use in food contact, housewares, cosmetics, and medical packaging. PHA has also been approved in medical applications such as sutures and drug delivery (pills).



Figure 3. Image of squid and spent shotgun wads.

Plastic shotgun wad production is in the billions annually and in the US over 3 million hunters self-identify as waterfowl hunters. Waterfowl hunters are among the most environmentally astute sportsmen and recognize the importance conservation. Biodegradable wads have importance beyond waterfowl hunting and should be used any time a shot is discharged adjacent to or over water or where the wad could be washed into a stream, river, or bay. This could occur in numerous situations including when hunting animals other than waterfowl, at skeet shooting ranges, conducting military training operations, or sport shooting recreationally off of vessels. The military also uses huge quantities of shotgun shells and has expressed interest in developing environmentally friendly alternatives that leave no trace in theaters of action (Fig. 4).



Figure 4. Sailors shooting 12 gauge shotguns off aircraft carrier USS Ronald Reagan. US NAVY PHOTO.

A grant from the Center for Innovative Technology’s Commonwealth Research Commercialization Fund (CRCF) program has provided support to continue testing of biodegradable wads. The CRCF advances science- and technology-based research, development, and commercialization to drive economic growth in Virginia by assisting organizations within the Commonwealth in commercializing qualified research or technologies.

¹ Fendal, L.S. and M.A. Sewell, 2009, Marine Pollution bulletin 58: 1225-1228.

² Farrell, P. and K. Nelson, 2013, Environmental Pollution 177: 1-3.

³ Chanprateep, S. 2010, Journal of Bioscience and Bioengineering 110(6): 621-632.

* The College of William & Mary has filed a patent application covering PHA wads and, in accordance with university policy, researchers share in any net revenues.