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FEASIBILITY OF LEAD-FREE PLASTIC FISHING TERMINAL TACKLE

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FEASIBILITY OF LEAD-FREE PLASTIC FISHING TERMINAL TACKLE– Lures, Jigs and Sinkers

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The Chelsea Center for Recycling and Economic Development, a part of the University of Massachusetts' Center for Environmentally Appropriate Materials, was created by the Commonwealth of Massachusetts in 1995 to create jobs, support recycling efforts, and help the economy and the environment by increasing the use of recyclables by manufacturers. The mission of the Chelsea Center is to develop an infrastructure for a sustainable materials economy in Massachusetts, where businesses will thrive that rely on locally discarded goods as their feedstock and that minimize pressure on the environment by reducing waste, pollution, dependence on virgin materials, and dependence on disposal facilities. Further information can be obtained by writing the Chelsea Center for Recycling and Economic Development, 80 Everett Avenue, Chelsea, MA 02150.

EXECUTIVE SUMMARY

The use of elemental lead (Pb) for commercial uses has raised concerns relative to its effect on worker safety, consumer safety, and certain environmental impacts. Of particular concern is the use of lead in such products as shot in ballistic shells and fishing sinkers and jig head lures. The potential for lead to be deposited in bodies of water from both commercial and recreational anglers is great since sinkers and jig heads are routinely lost during fishing as these products are deemed consumables by the trade.

This project investigated the potential to manufacture a cost-effective, environmentally preferred, alternative to lead-based sinkers and jig heads (a form of lure that typically has a heavy-weighted sphere encapsulating a hook and is decorated). The basic challenge was to develop a moldable plastic compound with a filler having a final product density similar to lead. The use of recycled plastic in its manufacturing was also an objective of the project.

The test used a commercial grade of 50/50 (by weight) talc-filled polypropylene manufactured from a leading plastic recycler and compounder. The plastic compound was molded in a 180-ton conventional horizontal molding machine in a four (4) cavity mold that formed a bolt-nut product without any problems. The product density was approximately 1.83. Because the density of this talc-filled plastic was not as great as lead, the terminal velocity, sink velocity rate, of the sample product did not match conventional lead-containing products. Therefore, a denser plastic compound must be found. Fillers to be further investigated include common and commercial grades of barium sulfate, hematite, and perhaps titanium. None of these additives should have any significant potential health concerns.

Assuming that a denser compound could be found or developed, the manufacturing process used was also evaluated to determine the approximate cost of a lead-free alternative and a unit cost of about $0.30 was estimated. This cost is much higher than a simple lead-containing sinker. Therefore, unless legislation is passed requiring the use of lead-free sinkers (as is occurring with shot from shot gun shells near watersheds), there does not appear to be an economic opportunity for plastic sinkers to compete with lead sinkers.

However, due to the higher costs and profit margins for jig heads, there may be an opportunity to market lead-free plastic replacements for value-added sinking fishing lures and jig heads. Therefore, numerous suppliers of jigs were contacted to verify whether a lead-free controlled sinking velocity jig head might an advantage to anglers. The jig makers that were contacted were interested in knowing of a controlled terminal velocity, lead-free substitute for their products. The use of recycled plastic was also of interest to them. It is recommended that a leading jig or lure manufacturer review these findings for accuracy and for commercial opportunities. If products can be identified that can accept the higher cost of the lead-free, recycled polymer lure/jig, then further economic analysis should be continued to establish exact compound and molding/mold costs.

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1. INTRODUCTION

Many long-accepted commercial uses of elemental, metallic lead (Pb) have raised concerns relative to lead's effect on worker safety, consumer safety, environmental impact and the ultimate disposal methods of lead based products at their end of life. Of particular concern is the use of lead in or near potable water sources such as wells, inland water bodies, ocean shorelines and especially reservoirs. In fact, certain states, i.e. New Hampshire, have enacted limited legislation restricting the use of lead in such products as shot in ballistic shells and angling sinkers. The potential for lead to be deposited in bodies of water from both commercial and recreational anglers is great since sinkers and jig heads are often lost when fishing occurs and these products are deemed consumables by the trade. In fact, because of California regulations, most, if not all lead based terminal tackle (e.g., lead sinker) suppliers provide the following warning on their products: "Warning. These products contain lead, a chemical known to the state of California to cause cancer & birth defects & other reproductive harm. Do not place your hands in your mouth after handling this product. Do not place the product in your mouth. Wash your hands after touching this product."

The product testing and development work described in this report was funded by the Chelsea Center for Recycling and Economic Development to investigate the potential to develop a cost-effective replacement to lead-based sinkers and jigs made of plastics, and possible waste plastics. The use of plastics with fillers added to enhance density is neither new nor innovative. The plastics industry typically uses such plastic compounds for products that require predetermined characteristics. For example, calcium carbonate and talc filled plastic compounds are available from plastic compounders located in Massachusetts.

From conversations with the Massachusetts Department of Fisheries it appeared that there could be significant market opportunities if such a safe and cost-effective lead sinker and fishing lure alternatives were found. From the Department it was suggested that the project initially seek a lead-free alternative to jig heads, as the price margin for jig heads is typically two to three times that for lead sinkers. A jig head is a form of lure that typically has a heavy-weighted sphere encapsulating a hook and is decorated. Many also contain brilliant and flashy specks and feathers to attract fish since fish are color blind.

The basic challenge to our work was to purchase an existing polymer compound or create a designer compound from a polymer that will have a density similar to lead and is moldable. Additionally, the use of recycled plastic was objective of the project.

2. TEST DESCRIPTION AND RESULTS

For these tests, a commercial grade of talc-filled polypropylene manufactured from a leading plastic recycler and compounder (Aaron Industries, Inc. of Leominster, MA) was used. Due to moldability issues, the maximum acceptable loading ratio of talc to plastic was 50/50 (weight by weight), an amount considerably higher than industry norm.

Aaron Industries, Inc. like other compounders, purchases commercial grades of fillers, i.e. talc, and ratio these fillers in a controlled process with virgin polymers, in this case polypropylene; to create a compound that can be molded into value added end products. This compound could also be made from recycled plastic with no adverse effects accept colorability (if the recycled plastic was not natural in color).

The 50% wt. talc-filled polypropylene compound was purchased by The Kelly Company and was in turn molded in a 180 ton conventional horizontal molding machine in a four (4) cavity mold that formed a bolt-nut shaped product at their Clinton plant. Its density was approximately 1.83 g/ml. This sample was molded without any problems and no loss in cycle time was experienced. The sample was then subjected to an aquatic sink/float tank to analyze the sinking characteristics of the modified polymer. The product sank at a slow rate. Because the density of the plastic compound was much less than that for lead (11 g/ml), the terminal velocity and sink velocity rate of the specimen did not match the conventional lead product.

The sample was then allowed to remain in the solution overnight to observe if any change in physical properties of the sample occurred. The following day the bolt had risen to the surface. The reason for the resurfacing was not investigated but the possibility exists that the compound imbibed oxygen or the surface was not sufficiently wetted, thus affecting its buoyancy.

In order to duplicate the terminal velocity of the conventional lead sinkers, a denser compound must be created. Because of lead’s high specific gravity of 11 g/ml, this is not an easy challenge. One firm, Ideas to Market, L.P., claims to have developed a titanium/polymer composite material that has the same density (11 g/ml) of lead. However, we did not price, nor test their specialty compound trade-marked Ecomass as this firm was researched after the test molding process was completed. This author doubts this claim somewhat as their compound is based solely on titanium and titanium’s density is only 4.5 g/ml compared to lead at 11 g/ml.

Based on the observation that the terminal velocity of the talc/polypropylene sample did not duplicate lead, it can be assumed that this material cannot substitute for lead fishing sinkers. However, since the sample’s density was substantially greater than unfilled plastic, the research team contacted numerous suppliers of jigs to verify whether a controlled velocity, lead-free jig head was an advantage to anglers. The contacts were identified via a search on the World Wide Web using search engines AOL, Google, and Yahoo. It was observed that the majority of jig manufacturers are located in the upper mid-west (Minnesota, Michigan) since jigs are extensively used in ice fishing and in the fishing for walleye, perch, and small mouthed bass. However, there are also some Massachusetts based lure manufacturers that manufacture and market jigs to the salt water fishing trade.

The jig makers that were contacted were interested in knowing of a controlled terminal velocity, lead-free substitute for their products. The use of recycled plastic was also of interest to them.

In order to develop a cost-effective lead-free product, the manufacturing process used was evaluated to determine the lowest cost manufacturing method and an approximate unit cost. The recommended method is to over-mold the density-modified polymer over a stainless steel fishing hook. This can be accomplished with the use of a standard vertical injection molding machine where as the hook is manually or automatically loaded into the mold and then the plastic is over-molded over the hook shank to encapsulate it. This semi-finished product can then be decorated (painted, deckled, coated, etc.) and then further enhanced with tail feathers or other fish attracting embellishments.

3. OTHER FILLERS AND PLASTICS

Although talc filled plastic compounds are commercially available, the density of the compounds are inadequate to match that of the higher specific gravity of lead. Other recommended non-lead fillers should be investigated. Fillers to be further investigated include common and commercial grades of barium sulfate, hematite, and perhaps titanium. None of these additives should present any significant potential health concerns. Please note that a typical MSDS for barium sulfate, the ingredient barium sulfate is listed as hazardous. However, upon further investigation it appears that this warning is for free barium sulfate in an airborne state as "long term inhalation of dust may lead to deposition in lungs in sufficient quantities to produce baritosis, a benign pneumoconiosis." Typically, a plastic molder would be purchasing the compound in modified form as a compound and not processing the filler as dust.

A recycled grade of engineered grade resin could also be used, or a standard commodity resin such as recycled polypropylene. Good target polymers for natural, non-pigmented lures or jig heads could be waste ABS (acetyl butadiene styrene) from used computer housings or polycarbonate from large non-carbonated potable water containers. The specific gravity of ABS is 1.08 compared to that of polypropylene of 0.903. Aaron Industries is capable of effectively compounding these filled polymers and no special permits should be required for their use.

The following table represents the varied specific gravity of some pre-selected compounds. All filler loadings are at 50% by wt. conditions.

Table 1: Calculation of Densities of Various Fillers and Plastics

Filler (specific gravity-g/ml)	In Polypropylene		In ABS	
	g/ml	lbs/ft3	g/ml	lbs/ft3
None	0.903	56.4	0.903	67.0
Talc (2.75)	1.826	114	1.826	120
Titanium (4.5)	2.702	169	2.702	174
Barium sulfate (4.5)	2.702	169	2.702	174
Hematite (5.1)	3.002	188	3.002	193
Lead (11.3)	6.102	381	6.102	387

4. COST ANALYSIS

To estimate the costs of producing a lead-free sinker alternative, the following assumptions and calculations were made:

A commercial, simple, eight (8) cavity tool for a vertical molding machine with one top half (A half) and two bottom halves (B half) is estimated to cost $20,000. This tool can fit a standard vertical molding machine having a tonnage capacity of 30 US tons. The shot size is 2.97 ounces based on general-purpose styrene (specific gravity 1.05). Thus with the 50% wt. ABS based compound and hematite, the shot size would be 8.74 ounces. With a sprue/runner assembly representing 30% wt. of the shot weight, one can mold a quantity of eight (8) jigs having a per piece weight of 0.721 ounces each. A jig of this weight represents a jig having a spherical physical dimension of 0.917 inches in diameter.

Based on an estimated cycle time of 45 seconds the injection molding machine is capable of molding 80 cycles an hour or 640 jig heads an hour or 399,360 jig heads each year. Ideally all of the runner scrap is recyclable back into the process at no loss. At a typical fully amortized molding operational hourly rate of $75.00 with operator the per piece jig head cost is $0.1172 each or $0.1234 with a 5% product loss built in. This does not include the cost of materials (compound or hook), mold amortization, decoration, or packaging.

Material cost: Estimated $2.00/lb = $2.00/16 ounces = $0.125/ounce divided by 0.721 ounces each or $0.1734 each without 5% loss or $0.1825 with 5% loss.

Mold cost: $20,000 amortized over 7 years or $20,000 (7 x 8 x 3 x 26) = $20,000 / 4,368 hrs. = $4.58/hr = $4.58/640 heads/hr = $0.007/head without 5% loss or $0.0074/head with 5% loss.

Molding: 8 hours/day, 3 days/week, and 26 weeks/year

Total Cost Estimates	No Waste	5% Waste
Molding	$0.1172	$0.1234
Material	$0.1734	$0.1825
Mold Cost	$0.007	$0.0074
Total Cost per Unit	**$0.30**	**$0.31**
Such unit prices could compete with jig-heads but probably not with common sinkers.		

The above estimates do not include the cost for the hook, packaging, or post-mold decoration.

In regard to material usage, the above project with a single 8-cavity mold would have the potential to divert 9,000 pounds of waste plastic from landfilling each year.

5. CONCLUSIONS AND RECOMMENDATIONS

Unless legislation is passed requiring the use of lead-free sinkers (as is occurring with shot from shot gun shells near watersheds), there does not appear to be an economic opportunity for plastic sinkers to compete with lead sinkers. Lead, although hazardous, is an inexpensive element to smelter, mine and mold. Further, all of the sinkers that the team investigated were made in developing counties such as Haiti were environmental legislation is lacking and worker safety is of much less of a concern than that in America.

There appears to be an opportunity to market lead-free plastic replacements for value added sinking fishing lures and jig heads that meet the following conditions:

- Where the sink velocity, termed terminal velocity, of a fishing jig adds value to the angler,
- Where there is a real concern or restriction on the use of lead-based fishing jigs,
- Where the environmental preferability of the product can be a selling point,
- Where the angler can accept an lead-free angling jig that has a larger volume head in comparison to a smaller lead-containing product,
- Where molding in a speckled or reflective additive identifies a benefit to attract fish and enhance the fishing experience,
- A combination of the above.

The research team recommends that a leading jig or lure manufacturer located in the Northeast preferably in Massachusetts review these findings for accuracy and for commercial opportunities. If fishing lure products can be identified that can tolerate the extra cost of the lead-free, recycled polymer, lure/jig, then further economic analysis should be continued to establish exact compound and molding/mold costs.

Barium sulfate should also be evaluated as a potential filler since this common mineral is transparent to translucent in crystal form and can be purchased colorless, white, blue, green, yellow, and red shades. As a result, if molded with natural recycled resins, a value-enhanced lure/jig could be developed (although fish are colorblind, anglers are not, and they tend to pay a premium for brightly colored lures/jigs). Other additives could also be included to enhance this value adding such as mica, feldspar and other environmentally friendly inorganic shiny additives.