INVESTIGATION ON BIO-DEGRADABILITY OF BIO-ACTIVE COATING POWDERS SUCH AS SEA SHELL, EGG AND AL_2O_3 UPON TEFLON, PVC, NYLON AND POLYURETHANE POLYMERS

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Abstract: Present work deals with understanding the Biodegradability of polymers which are coated with the bio-active coating materials like Al_2O_3, egg and sea shell powder. The polymers are coated with Plasma spray deposition to ensure proper coating thickness and also to maintain phase purity of powder samples. The powders which were used to prepare coating materials were derived from natural sources like Aluminium oxide, egg shells and sea shells. The extracts are sources of calcium, fibres etc. and hence the coating materials are naturally bio-active and biocompatible. Bio-active coating on Bio-implants are very essential to improve the life span of Bio-implant and also resulted in improvement of hydrophobic properties of Bio-implants. During the biodegradability test it was found that sample polymers coated with sea shell and egg shell yielded better results compared to uncoated materials and also few combinations have shown excellent results in comparison with Hydroxyapatite. The outcomes of the test also proved improved hydrophobic properties of coated polymers.

KEY WORDS: Biodegradable, Bio-Active Coating, Al2O3, Egg and Sea Shell Powder on Teflon, PVC, Nylon and Polyurethane,

1. *Introduction*:

Biodegradation is the disintegration of materials by bacteria fungi or other biological means. The demand for testing biodegradability has come about as result of industry produced polymers and pack- aging materials claimed to be biodegradable, the Biopolymers research program was started with financial support in order to develop new kinds of polymers. Projects on thermoplastic starch, biodegradable polyesters, and polysaccharide/ surfactant interactions, processing studies, and the development of biodegradability testing methods are included. Mass loss of the biodegradable polymer implants occurs after the loss of mechanical properties. The mass loss represents absorption of the polymer. The mass (mg) of the samples was measured test methods by Prior to mass loss determination, the samples were extracted from the containers and dried in a vacuum for four days. Thereafter they were weighed and mass loss (%) was determined by comparing the remaining mass to the initial mass determined prior to incubation in the hydrolytic in vitro conditions.

1.1 Hydrolytic in vitro conditions: Hydrolytic in vitro conditions for the test specimens were created according to the guidelines of the existing material test standards for biodegradable polymer materials ISO (140-141). Accordingly, after the preparation of the test specimens, the specimens and samples for mechanical, biomechanical and material property tests were placed in individual containers filled with PBS (pH 7.4±0.2) and incubated at 37±1 °C until testing which was conducted at certain time points during the hydrolytic in vitro period as per ISO(ISO 6721-1). The 0-2week tests were conducted after 24 hours' incubation to ensure relaxation of the biodegradable implants at body temperature and water absorption prior to testing. The incubation PBS was changed and pH measured bi-weekly. [1] Enamelling, producing excellent glass/metal adhesion with well-attached bioactive particles on the surface, is a promising method of forming reliable and lasting implants which can endure substantial chemical and mechanical stresses.[2] Excellent adhesion to alloys has been achieved through the formation of 100–200 nm thick interfacial layers (Ti_5Si_3 on Ti-based alloys and CrO_x on Co–Cr). Finally, glass coatings, approximately 100 nm thick, have been fabricated onto commercial Ti alloy-based dental implants.

2. Procedure for prepare the solution

PBS (Phosphate Buffer Saline) **:-** Is a buffer solution commonly used in biological research, It is a salty solution containing sodium chloride, sodium phosphate and potassium chloride and potassium phosphate the buffer helps to maintain a constant pH, The osmolality and ion concentrations of the solutions match those of the human body (isotonic). Phosphate buffer system operates in the internal fluids of all cells. It consists of di-hydrogen phosphate ions as the hydrogen ion donor (acid) and hydrogen phosphate ion as the ion acceptor (base).

2.1 preparation of PBS solution for 1 litre as follows

- Take 800 ml of distilled water:
- Add 8 g of NaCl. (Sodium chloride)
- Add 0.2 g of KCl. (Potassium chloride)
- Add 1.44 g of Na_2HPO_4. (Sodium hydrogen phosphate)
- Add 0.24 g of KH_2PO_4. (Potassium dihydrogen phosphate)
- Adjust the pH to 7.4 with HCl (Hydrogen chloride) by using litmus
- Add distilled water to a total volume of 1 litre

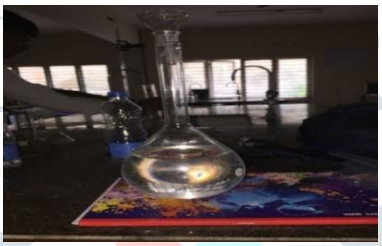


Fig.1: 800 ml of distilled water as shown in figure

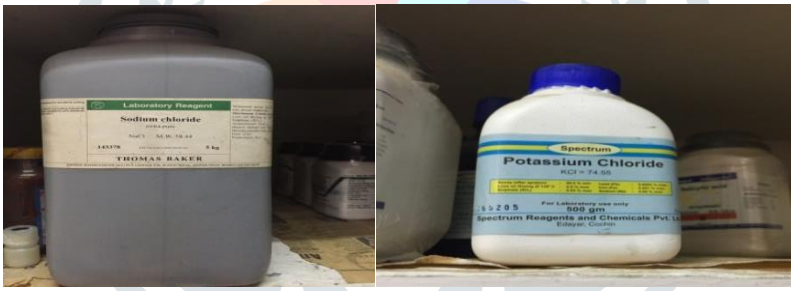


Fig .2: NaCl (Sodium chloride) and KCl. (Potassium choloride)

Fig.3: Na_2HPO_4. (Sodium hydrogen phosphate) and KH2PO4. (Potassium di-hydrogen phosphate)

Fig.4: checking pH to 7.4 value

3. Preparation of PBS and Bio-degradability test specimens.

Preparation of PBS

- Prepare the solution as per the solution standards called (PBS) phosphate buffer saline.
- Take the 1 litter Jar and fill the solution up to 1 litter of Phosphate buffer saline.
- Before dip the materials weigh the coated materials in the micro weighing machine.
- Immerse the specimen completely in prepared solution as shown in the fig 5.
- Place biker inside the incubator at temperature 37 °C±1 in the incubator up to 0-2 weeks.
- Then finally remove the specimens from the incubator after two weeks from the incubator and weigh the materials and find out the error or variation before test and after test.

Fig. 5: Specimens Are Placed In the Solution and Weighting Machine

Preparation test specimen sample

Table no:1 test samples

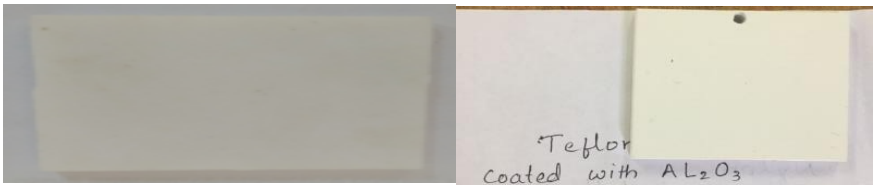
Polymers / Powder / Samples	TEFLON	NYLON	Polyvinylchloride	Polyurethane
Uncoated	A:Uncoated Teflon	B: Uncoated NYLON	C: Uncoated PVC	D:Uncoated PU
Al_2O_3	A1: Al_2O_3 coated Teflon	B1: Al_2O_3 coated NYLON	C1: Al_2O_3 coated PVC	D1: Al_2O_3 coated PU
Eggshell	A2: Eggshell coated Teflon	B2: Eggshell coated NYLON	C2: Eggshell coated PVC	D2: Eggshell coated PU
Seashell	A3: Seashell coated Teflon	B3: Seashell coated NYLON	C3: Seashell coated PVC	D3: Seashell coated PU

4. Biodegradability test specimens uncoated and coating samples

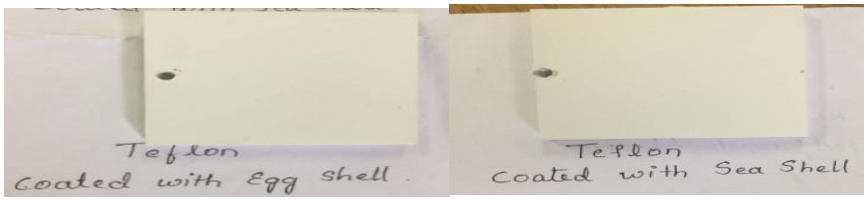
Bio-degradability test conducted on selected polymers both coated and uncoated specimens, Bio-degradability properties plays a very vital role in Bio-implants.

Bio-degradability test on Teflon with uncoated and coated samples

Bio-degradability test conducted on uncoated Teflon, Al_2O_3 coated Teflon, Egg shell coated Teflon and sea shell coated Teflon are shown in the fig: 6.



Sample A Sample A1

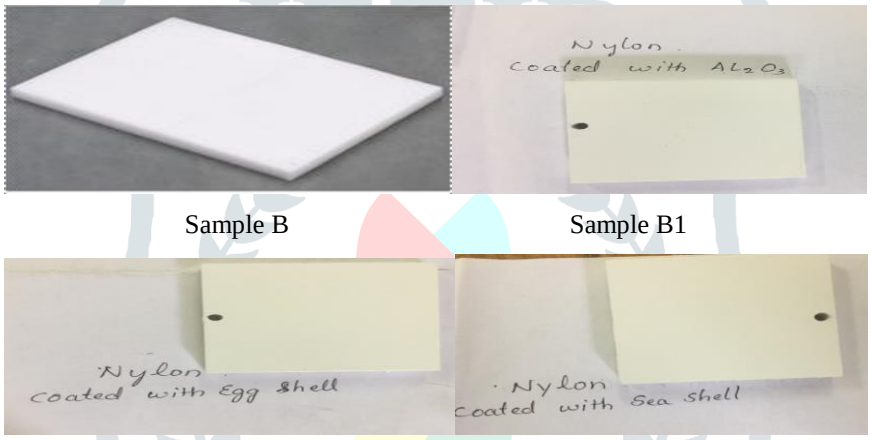


Sample A2 Sample A3

Fig. 6: Teflon uncoated and coated specimens after Bio-degradability

Bio-degradability test on nylon with uncoated and coated samples

Bio-degradability test conducted on uncoated Nylon, Al_2O_3 coated Nylon, Egg shell coated Nylon and sea shell coated Nylon are shown in the fig: 7.



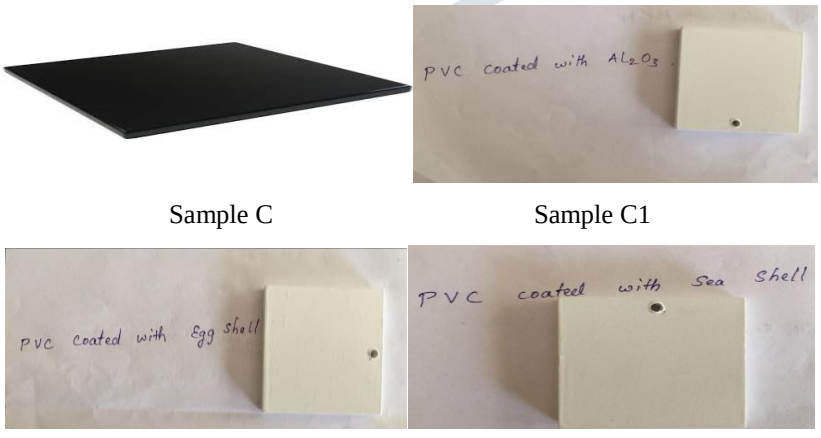
Sample B Sample B1

Sample B2 Sample B3

Fig. 7: Nylon uncoated and coated specimens after Bio-degradability

Bio-degradability test on PVC with uncoated and coated samples

Bio-degradability test conducted on uncoated PVC, Al_2O_3 coated PVC, Egg shell coated PVC and sea shell coated PVC are shown in the fig: 8.



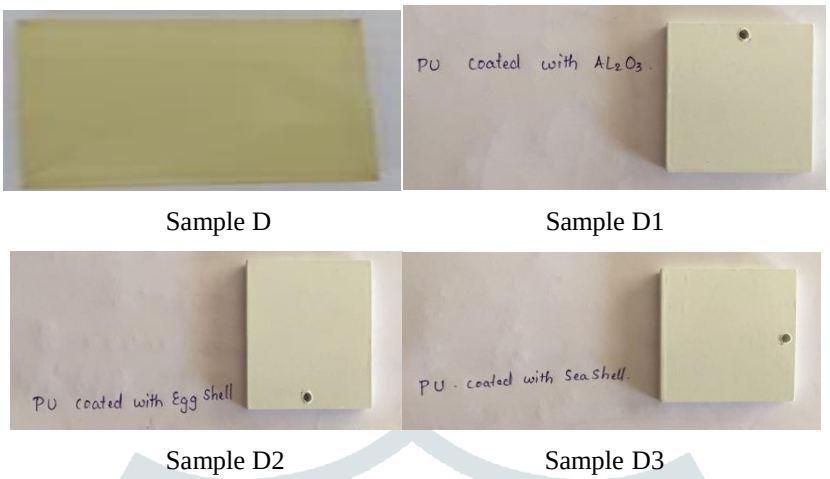
Sample C Sample C1

Sample C2 Sample C3

Fig. 8: PVC uncoated and coated specimens after Bio-degradability

Bio-degradability test on polyurethane with uncoated and coated samples

Bio-degradability test conducted on uncoated polyurethane, Al_2O_3 coated polyurethane, Egg shell coated polyurethane and sea shell coated polyurethane are shown in the fig: 9.



Sample D Sample D1

Sample D2 Sample D3

Fig.9: Polyurethane uncoated and coated specimens after Bio-degradability

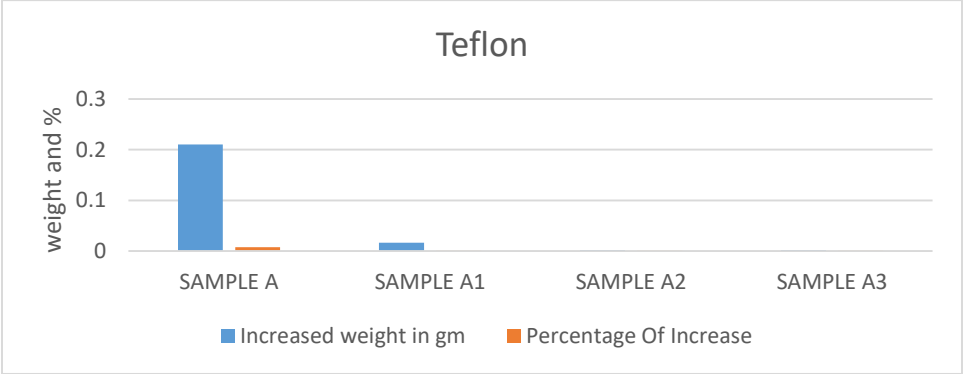
5. Results and Discussion

Bio-degradability test results on uncoated and coated samples are discussed and summarized

Bio-degradability results on Uncoated and coated Teflon samples

Table No: 2 biodegradability results on Teflon

Materials	Before test specimen weight in gm	After test specimen weight in gm	Increased weight in gm	Percentage Of Increase
SAMPLE A	26.2122	26.4211	0.2100	0.797%
SAMPLE A1	27.6119	27.6283	0.0164	0.0594%
SAMPLE A2	27.4269	27.4290	0.0021	0.0076%
SAMPLE A3	27.4566	27.4586	0.002	0.0073%



Graph 1: Bar graph of Teflon uncoated and coated

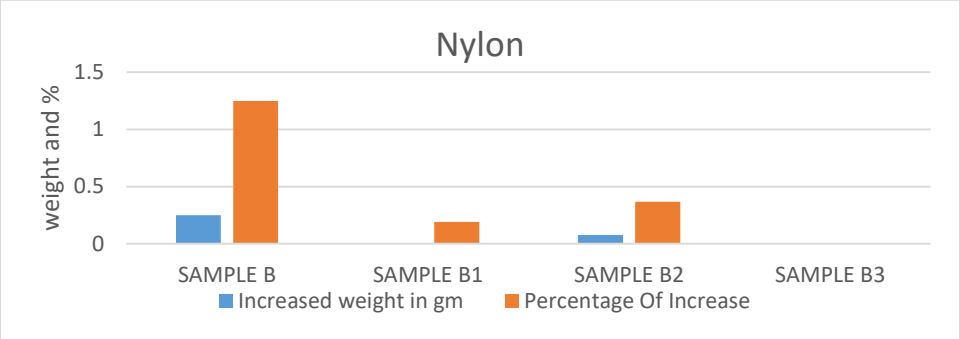
After Bio-degradability test results are compared with coated and uncoated materials, the percentage of solution absorption of Teflon coated with bio-active coating materials are very less when compared to uncoated materials. So the hydrophobic properties of material is increased after coating, especially Teflon coated with egg and sea shell are showing very good results (negligible). Bio-degradability test results are shown in table 2 and also shown in the graph 1.

Bio-degradability results on Uncoated and coated nylon samples

Table No: 3 biodegradability results on Nylon

Materials	Before test specimen weight in gm	After test specimen weight in gm	Increased weight in gm	Percentage Of Increase

SAMPLE B	20.0533	20.3045	0.2512	1.25
SAMPLE B1	20.8722	20.8762	0.004	0.191
SAMPLE B2	20.6849	20.7618	0.076	0.367
SAMPLE B3	20.9393	20.9395	0.0002	0.00095



Graph 2: Nylon uncoated and coated samples

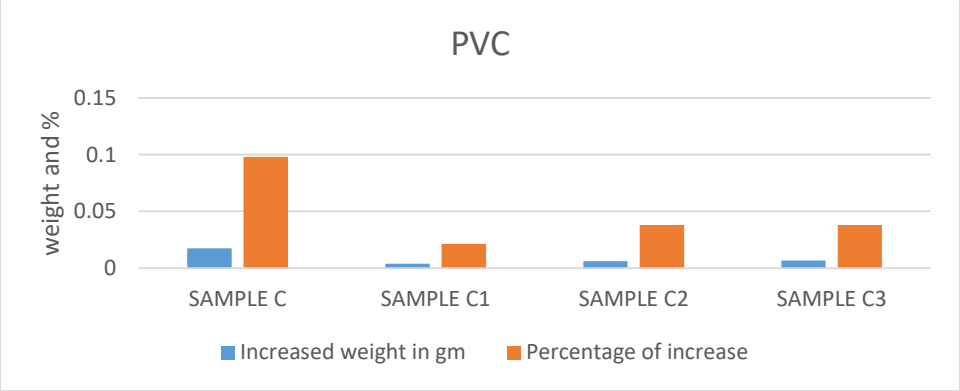
The percentage of solution absorption of nylon coated with bio-active coating materials are very less when compared to uncoated materials. So the hydrophobic properties of material is increased after coating, especially nylon coated with sea shell are showing very good results (negligible).

Bio-degradability test results are shown in table 3 and also shown in the graph 2.

Bio-degradability results on Uncoated and coated PVC samples

Table No: 4 biodegradability results on PVC

Materials	Before test specimen weight in gm	After test specimen weight in gm	Increased weight in gm	Percentage of increase
SAMPLE C	17.5878	17.6051	0.0173	0.098
SAMPLE C1	17.7728	17.8112	0.0038	0.0213
SAMPLE C2	17.5323	17.5384	0.0061	0.0379
SAMPLE C3	17.6525	17.6592	0.0067	0.038



Graph 3: PVC uncoated and coated samples

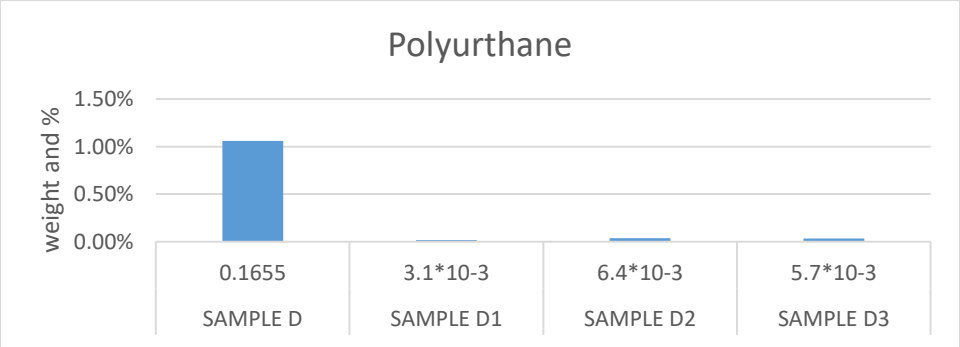
Based on the graph PVC coated with AL2O3 is least amount of increased in weight percentage.

The percentage of solution absorption of PVC coated with bio-active coating materials are less when compared to uncoated materials. So the hydrophobic properties of material is increased after coating, Bio-degradability test results are shown in table 4 and also shown in the graph 3.

Bio-degradability results on Uncoated and coated polyurethane samples

Table No: 5 biodegradability results on polyurethane

Materials	Before test specimen weight in gm	After test specimen weight in gm	Increased weight in gm	Percentage Of Increase
SAMPLE D	5.5269	15.6923	0.1655	1.06%
SAMPLE D1	16.9389	16.9420	3.1*10-3	0.018%
SAMPLE D2	16.7535	16.7599	6.4*10-3	0.038%
SAMPLE D3	16.7836	16.7893	5.7*10-3	0.034%



Graph 4: Bar graph of Polyurethane uncoated and coated

The percentage of solution absorption of polyurethane coated with bio-active coating materials are very less when compared to uncoated materials. So the hydrophobic properties of material is increased after coating, all the three samples are showing very good results. Test results are shown in table 5 and also shown in the graph 4.

6. *Conclusion*

From the experiment conducted, the following conclusions could be drawn:

- Plasma spray deposition gives proper coating thickness and phase purity of powder samples was retained after deposition.
- The powders which were used to prepare coating materials are derived from a natural sources like Aluminium oxide, egg shells and sea shell. The extracts are sources of calcium, fibres etc. So the coating materials are naturally bio-active and biocompatible.
- In biodegradability test all polymers coated with sea shell and egg shell are showing very good results compared to uncoated materials and also other coated combinations.
- Nylon in combination with sea shell coating, gave best result than other three polymers.

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