The focus of this study is on developing linear low density polyethylene (LLDPE) with higher levels of bio and photo degradability. For this it was blended with a biodegradable polymer, namely polyvinyl alcohol (PVA). After characterizing these blends by various analytical techniques they were subjected to weathering and UV irradiation studies in the presence of different pro-oxidants, viz. titanium dioxide (rutile and anatase), cobalt stearate and vegetable oil individually and in combinations. These partially degraded samples were subjected to various analytical and property evaluation tests to estimate the extent of degradation. Subsequently, these samples were subjected to biodegradation studies, one employing a culture medium containing a consortium of *Vibrio sp.* bacteria and the other, soil degradation involving burial of the samples in garden soil. After due passage of time the samples were again subjected to various analytical and property evaluation tests to determine the extent of biodegradation. In addition, experimental techniques were developed for preparing nano-TiO$_2$ in the laboratory. These samples were characterized and their pro-oxidant activity compared with that of commercial rutile and anatase.

The blending of PVA with LLDPE has led to a marginal loss of mechanical properties such as tensile strength and elongation at break. But the modulus of the
blends increased as the PVA content increased. Thermogravimetric analysis and differential scanning calorimetry established that the thermal properties of the blends are not much different from those of LLDPE. Water absorption studies on the blends proved that they absorbed somewhat more water than pure LLDPE. This is a factor favourable to biodegradation.

These samples were first subjected to weathering and UV irradiation each for 600 hours as the first step of the degradation process. These studies were done in the presence of three pro-oxidants namely titanium dioxide, cobalt stearate and vegetable oil. Judicious combinations of these pro-oxidants were employed for the studies. The extent of degradation of the samples was estimated by tensile property measurements, FTIR, MFI, weight loss, DSC and SEM. It was concluded that a combination of cobalt stearate and vegetable oil is the best choice for giving maximum degradation of these blends by both degradation techniques.

Partially degraded samples from the above studies were subjected to biodegradation by two methods namely (i) culture medium containing a bacterial consortium of *Vibrio sp.* and (ii) burial in garden soil for 15 weeks each. As in the earlier case, property evaluation and analytical studies were done on the samples. It was observed that the degraded samples containing cobalt stearate showed maximum degradability during the biodegradation step also.

Experimental studies done in the laboratory to develop nanoanatase (TiO₂) produced anatase of approximately 6nm crystallite size. Calcination time was optimized for the preparation of these samples.

The overall results prove that blending LLDPE with PVA is a promising method for making LLDPE more degradable. Blending with PVA does not cause
any deterioration of the properties of LLDPE. Among the pro-oxidants studied, cobalt stearate and vegetable oil combination gives the best performance as far as photo degradation and subsequent biodegradation are concerned. Nano-TiO$_2$ developed in the laboratory has also considerable pro-oxidant activity.

Photo degradation followed by biodegradation holds great promise for making LLDPE degradable by the combined technique of blending with PVA and addition of pro-oxidants. By this procedure, LLDPE can be broken down to fragments in a reasonable amount of time and assimilated into the environment.

The future outlook

- In this study these *Vibrio sp.* were selected because they are native to the Cochin backwater area. But there are other well known species which are known to attack PVA. Studies in that direction can be taken up in the case of LLDPE/PVA blend.

- LLDPE can be blended with a combination of biodegradable substances rather than PVA alone. Thus substances like starch, chitosan, polycaprolactone, polyhydroxybuterate, PVA etc can be used in combinations for blending with LLDPE to study biodegradability.

- Photo and UV degradation studies have been done in this study in the presence of either TiO$_2$ or cobalt stearate in combination with vegetable oil. It is worth studying how far a combination of TiO$_2$ and cobalt stearate in the presence of vegetable oil will function as far as degradability is concerned.

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Modification of Linear Low Density Polyethylene for Improved Photo and Biodegradation