A METHOD OF SYNTHESIS OF PBAT USING GROUP 4 AND GROUP 13 INITIATORS

IITM Technology Available for Licensing

Problem Statement

- **Biodegradable poly(butylene adipate-co-terephthalate) PBAT** synthesis offers a **sustainable alternative** to petroleum-based plastics, reducing environmental pollution and supporting circular economy goals in packaging and agriculture.
- **Existing aliphatic polyesters** (e.g., PLA, PCL) suffer **high costs and poor mechanics**; while aromatic PET **lacks biodegradability**, limiting widespread eco-friendly applications.
- **Conventional PBAT syntheses** yield **moderate molecular weights** (<300 kDa) with **side-reactions**, **long reaction times**, and require **complex co-catalysts**, affecting processability and scalability.
- There is a need for **a novel initiator that uses earth-abundant metals** to achieve **ultra-high molecular weight** PBAT (>300 kDa) with narrow PDI at simpler conditions, with improved properties.

Intellectual Property

- IITM IDF Ref 2887
- **IN 202441065905 Patent Application**

TRL (Technology Readiness Level)

TRL 4 Technology Validated in Lab

Technology Category/ Market

Category- Chemistry and Chemical Analysis

Industry:

Chemicals manufacturing; Plastics and Polymers Industry

Applications:

Packaging Films- Compostable bags, cling films, and pouches; Agricultural Films- Mulch films and crop-protection sheets; Disposable Tableware: Cutlery and plates; Courier Bags- Biodegradable mailing envelopes; Textiles & Apparel- Fibers and non-woven fabrics; Pharmaceutical Materials- Biodegradable drug-delivery matrices.

Market report:

The global PBAT market was valued at USD 1,928 million in 2024 and is projected to reach USD 4,792 million by 2035, growing at a CAGR of 8.6%

Research Lab

Prof. Debashish Chakraborty
Dept.of Chemistry

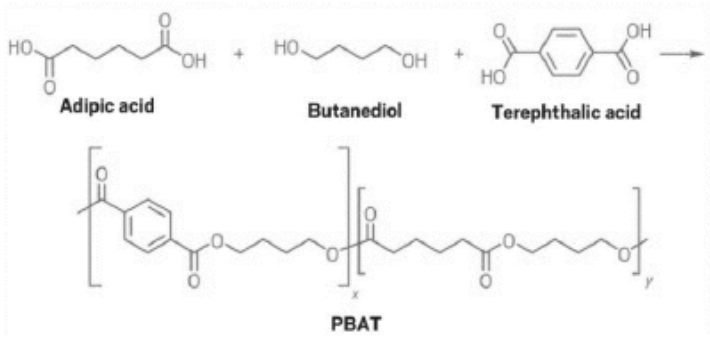


Figure: PBAT is an aliphatic-aromatic, biodegradable random copolymer. It is a copolyester made from adipic acid (CAS No. 124-04-9) , 1,4-butanediol (CAS No. 110-63-4), and terephthalic acid (CAS No. 100-21-0). It is structurally composed of a chemical unit of butylene adipate and butylene terephthalate.

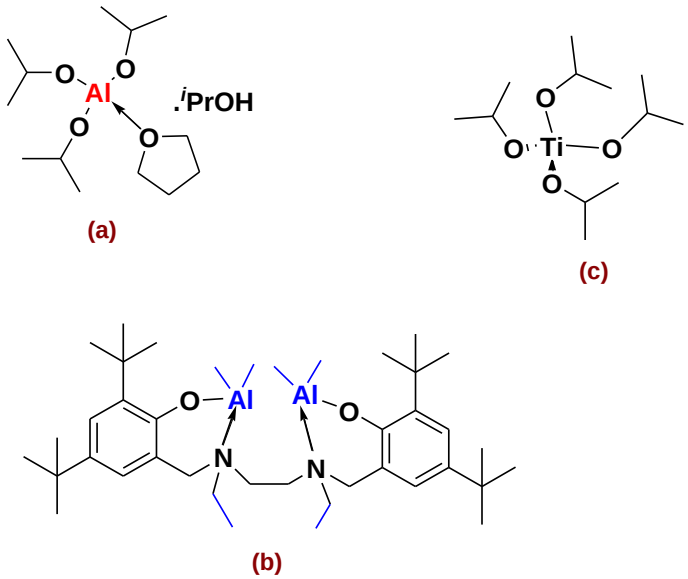


Figure: (a) shows the structure of Aluminum(III) isopropoxide isopropanol adduct **(b)** shows the structure of bimetallic complex of aluminium(III) **(c)** shows the structure of titanium propionate adduct

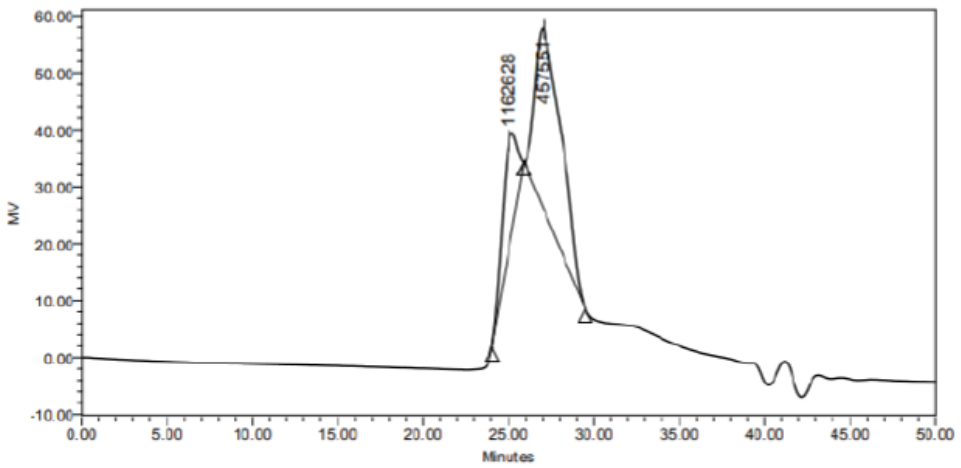
CONTACT US

Dr. Dara Ajay, Head TTO
Technology Transfer Office,
IPM Cell- IC&SR, IIT Madras

IITM TTO Website:
https://ipm.icsr.in/ipm/

Email: headtto-icsr@icsrpis.iitm.ac.in
ttooffice@icsrpis.iitm.ac.in

Phone: +91-44-2257 9756/ 9845



GPC Results

	Dist Name	Mn	Mw	MP	Mz	Mz+1	Mv	Poly dispersity	MW Marker 1
1		1146980	1176312	1162626	1206337	1236645		1.025573	
2		359234	395858	457551	431866	465068		1.101951	

Figure: The molecular weight of synthesized PBAT is in the range of 24000-12000 Daltons and a polydispersity index greater than 1

Technology

- Equimolar dimethyl terephthalate and 1,4-butanediol (0.15 mol each) are esterified at 150–200 °C for 1.5–4 h under N_2 (45 mL/min), removing methanol to form bis(hydroxyalkyl) intermediates
- **Upon methanol cessation, adipic acid and 1,4-butanediol (0.15 mol each) are added; reactor heated to 210–230 °C for 6 h to distill water, driving polycondensation**
- Pressure lowered to ~0.01 mbar; temperature ramped to 280–300 °C over 20–30 h, yielding viscous PBAT with molecular weights up to ~1.15×10^6 g/mol.
- Employs 0.05 wt% Group 4 (tetraisopropyl titanate) or Group 13 (THF-coordinated Al-propoxide/bimetallic Al) initiators, offering tunable reaction times (2–5 h for step a; 20–28 h for step b)
- Crude PBAT is suspended in $CHCl_3$, filtered, then vacuum-dried 8–10 h; final polymer exhibits PDI > 1.0 and Mn in the range 2.4×10^4–1.15×10^6 Da.

Key Features / Value Proposition

- Achieves PBAT molecular weights up to ~1.15×10^6 g/mol, surpassing literature reports (<3×10^5 Da) for superior mechanical strength.
- Utilizes inexpensive, non-toxic Group 4 (Ti) and Group 13 (Al) initiators, avoiding precious or hazardous metals common in other systems.
- Simplifies formulation by omitting additional co-catalysts, reducing material costs and post-processing purification steps.
- Delivers polymers with PDI ≈1.0–1.18, enabling uniform melt behavior and consistent performance in film-blowing or extrusion processes.
- Combines esterification and polycondensation in a single reactor under moderate temperatures (150–280 °C) and reduced pressure, minimizing reaction time and energy.

Entry	Initiator	Time (h)	Conversion(%)	M_n (g mol^{-1})	PDI	Isolated PBAT (g)
1	A	3, 22	>99	3,36,082	1.18	52
2	B	5, 28	>99	11,46,980 3,59,234	1.021.10	43
8	C	2, 20	>99	24,477	1.10	21

Figure: Polymerization for PBAT synthesis using **(A)** Aluminum(III) isopropoxide isopropanol adduct **(B)** bimetallic complex of aluminium(III) and **(C)** titanium propionate adduct

CONTACT US
Dr. Dara Ajay, Head TTO
Technology Transfer Office,
IPM Cell- IC&SR, IIT Madras

IITM TTO Website:
https://ipm.icsr.in/ipm/

Email: headtto-icsr@icsrpis.iitm.ac.in
ttooffice@icsrpis.iitm.ac.in
Phone: +91-44-2257 9756/ 9845