

Introduction

Melt strength (MS) of polypropylene (PP) has been modified utilizing benzophenone (BPH) as photoinitiator (PI) along with UV radiation

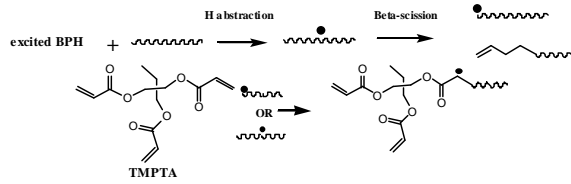
Limitations of the process: long radiation time needed

Trimethylpropane triacrylate (TMPTA) was used as co-agent to decrease radiation time

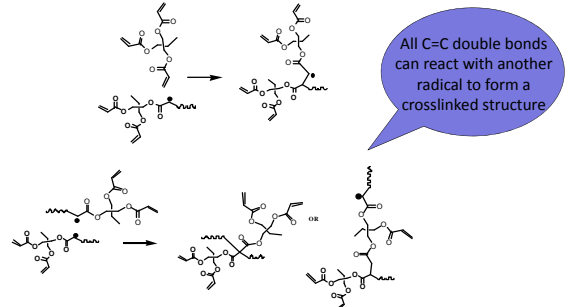
Why TMPTA? Fast kinetics; Branching at low percentages

Mechanism:

- A stable radical center is formed



Challenge: High gel content

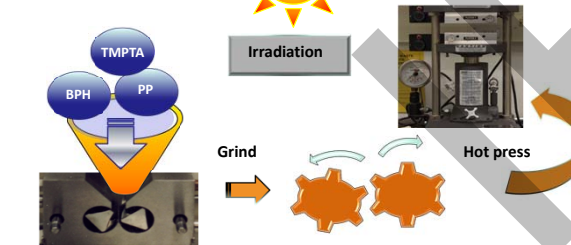


Objective: Formation of long chain branching (LCB) rather than crosslinking using TMPTA along with photoinitiator in UV modification

Processing steps & Design of experiments

Mixing photoinitiator (PI), PP and TMPTA

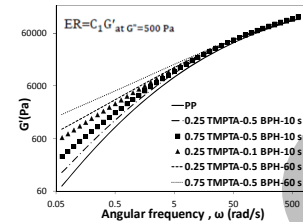
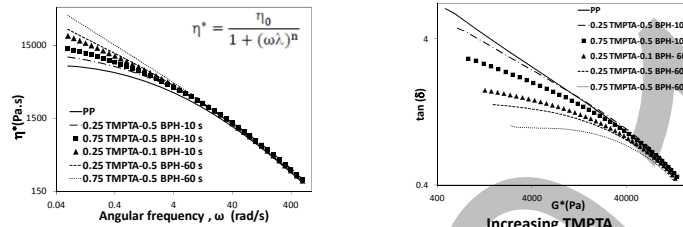
Photoinitiator: Benzophenone (BPH)



Process variable (units)	Range
Coagent (TMPTA) concentration (wt %)	0.25-0.75
Photoinitiator (PI) concentration (wt %)	0.1-0.5
Duration of radiation (s)	120-600

2³ Factorial design
 Response variables:
 - Viscoelastic properties
 - Gel content

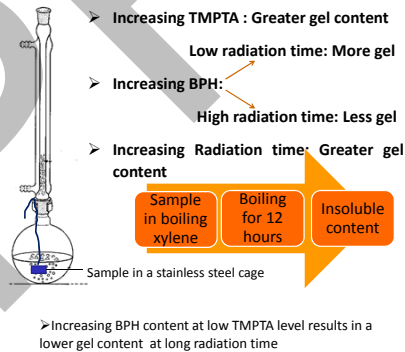
Rheological characterization: Viscoelastic properties



Run ID	Coagent (wt-%)	BPH (wt-%)	Time (min)	n	λ (s)	η ₀ (kPa)	ER
1	0.25	0.1	10	0.57	12.7	1.3	0.25
2	0.75	0.1	10	0.57	12.8	1.3	0.26
3	0.25	0.5	10	0.53	18.4	3.3	0.45
4	0.75	0.5	10	0.53	18.9	3.1	0.48
5	0.25	0.1	60	0.50	42.1	22.1	1.05
6	0.75	0.1	60	0.55	111.5	133.4	2.02
7	0.25	0.5	60	0.49	93.0	138.2	1.55
8	0.75	0.5	60	0.52	627.1	2,945.4	2.97
PP	0	0	0	0.61	8.8	0.6	0.13

Larger η*·ω and G'·ω at terminal region
 Broader molecular weight distribution
 Larger λ and η₀ and more shear thinning

Gel content



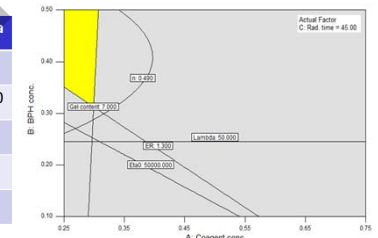
Run ID	Coagent-A (wt-%)	BPH-B (wt-%)	Time-C (min)	Gel Content (%)
1	0.25	0.1	10	1.2
2	0.75	0.1	10	6.2
3	0.25	0.5	10	5.9
4	0.75	0.5	10	13.3
5	0.25	0.1	60	7.5
6	0.75	0.1	60	36.1
7	0.25	0.5	60	5.6
8	0.75	0.5	60	26.4

Greater concentration of radicals increases the probability of combination between a stabilized radical center and another radical with no TMPTA in its backbone => less crosslinking

Optimized processing conditions

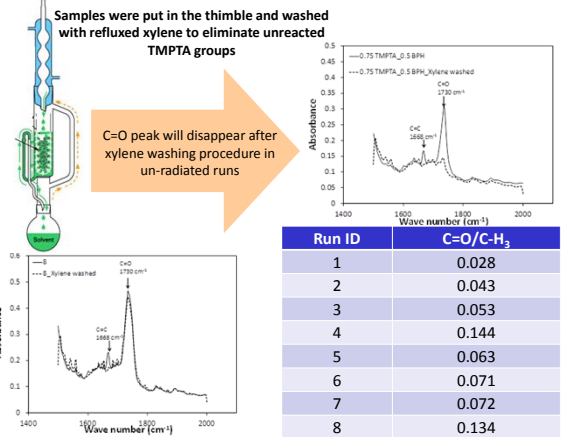
The following criteria were used to find the processing window that results in the maximum long chain branching content with the lowest crosslinking

Response	Criteria
n	<0.49
η ₀ (Pa.s)	>50000
λ (s)	>50
ER	>1.3
Gel content (%)	<7



FTIR spectroscopy

FTIR test was conducted on the runs after washing with xylene to verify TMPTA insertion in the PP chain



Concluding remarks and future steps

Modification of PP via photoinitiation reaction was carried out in the presence of TMPTA as a coagent

Increasing coagent content, or BPH content, or radiation time, will all lead to more shear thinning behavior and an increase in η₀, λ and ER due to formation of LCB

It was confirmed via FTIR tests that increasing coagent content, or BPH content, or radiation time, leads to greater insertion of TMPTA monomer in PP chains, which results in formation of more long chain branches

Future steps

Continuous modification process

Bibliography

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