PVC 4 CABLES

ALTERNATIVE TO MEDIUM-CHAIN CHLORINATED PARAFFINS (MCCPs)…. IN FLAME RETARDANT PLASTICIZED PVC COMPOUNDS

Camillo Cardelli
Senior Researcher &
Co-Founder, iPOOL

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an ecvm platform

ABOUT IPOOL

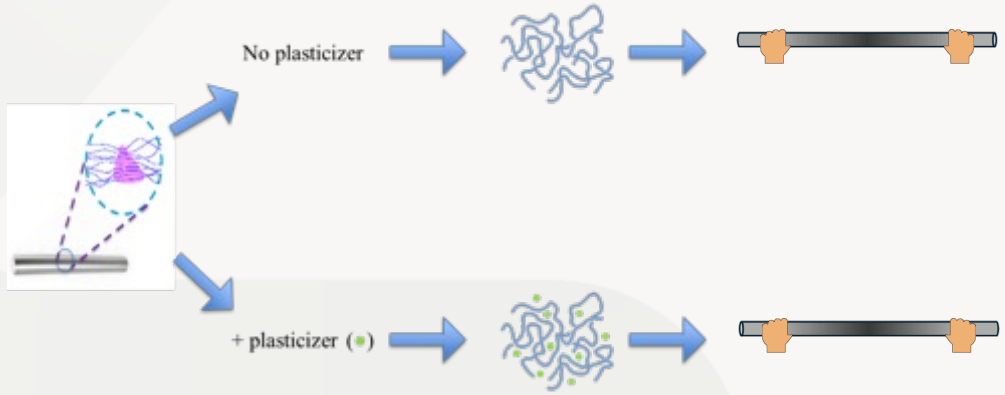
IPOOL is R&D – Technology company, Spin-Off company of Italian National Council of Research institute (CNR), established on July 2011 in Pisa (ITALY).

IPOOL, working in international projects from Europe to Middle East, from Russia to Asia, from Northern to Southern America, is technical specialist in **cables**, **ACP composite panels**, **TPO/PVC/bitumen roofing** membranes, **pipes** and **rubbers**.

- Flame retardant fillers for PVC and halogen free compounds
- Design and testing of new additives for compounds
- Cost and performances optimisation of PVC and HFFR compounds.
- Equipment for compounding: twin screw extruders, co-kneaders, internal mixers, …
- Optimization of extrusion of insulation and sheathing compounds
- Laboratory testing equipment for R&D and QC
- Selection and training of technical people for R&D activities (experimental thesis)
- Design of marketing strategy for new products and new additives

PLASTICIZER

- A plasticizer is a substance that is incorporated into a material (usually a plastic or elastomer) with the purpose of increasing its flexibility and processability.



A good plasticizer, to be such, must:

- Show good compatibility with PVC
- Must not be toxic
- Must not interact negatively with other additives present in the formulation
- Have low volatility

⇒ The best plasticizer should give LOW FLAMMABILITY, or, even better, FLAME RETARDANCY

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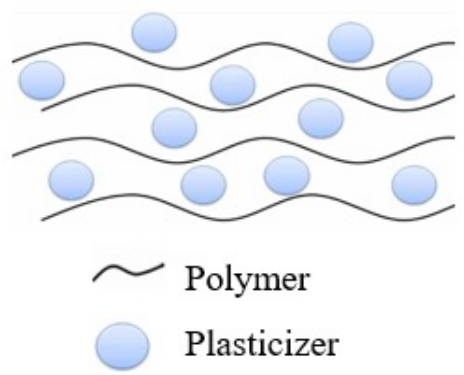
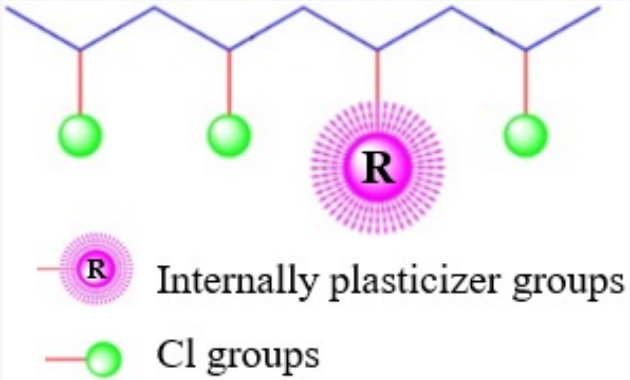
CLASSIFICATION OF PLASTICIZER

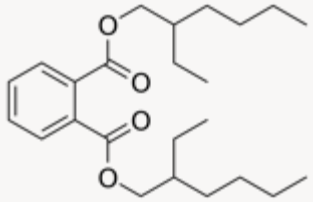
External plasticizers



Internal plasticizers

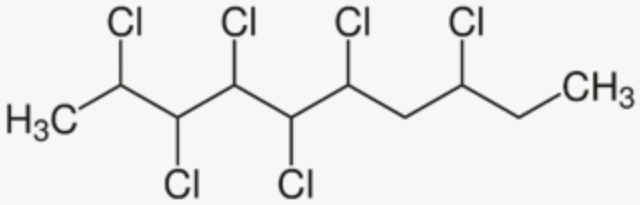


Primary plasticizers



Dioctyl Phthalate

Secondary plasticizers



Chlorinated Paraffins

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OBJECT OF THE WORK

PROBLEM → Plasticizer migration →

- Decrease mechanical properties
- Reduces flexibility
- Increases hardness
- Issue related to releasw of the plasticizer in the ambient

OBJECTIVES →

- Development of a method to evaluate the migration of various types of plasticization
- Development of highly flame-retardant and low-smoke formulations

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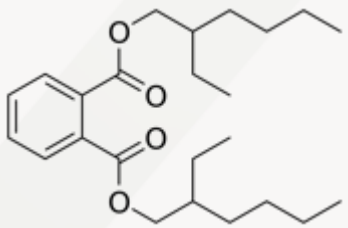
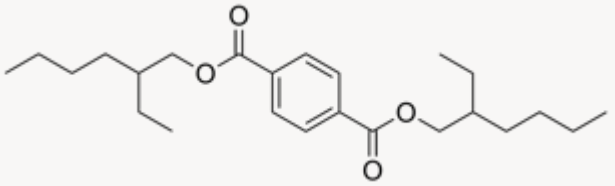
PRIMARY PLASTICIZER



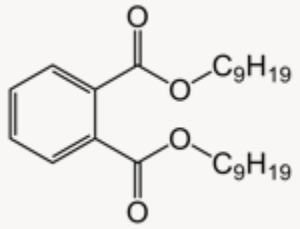
DOP
(Dioctyl Phthalate)

- PM: 390,6
- Density: 0,98 g/mL
- Teb: 220°C



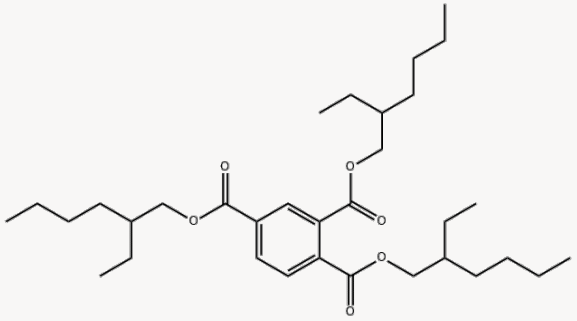
DOTP
(Dioctyl Terephthalate)

- PM: 390.6
- Density: 0,99 g/mL
- Teb: 400°C



DINP
(Diisononyl Phthalate)

- PM: 418,6
- Density: 0,98 g/mL
- Teb: 244°C



TOTM
(Tris 2-Ethylhexyl Trimellitate)

- PM: 546,8
- Density: 0,99 g/mL
- Teb: 414°C

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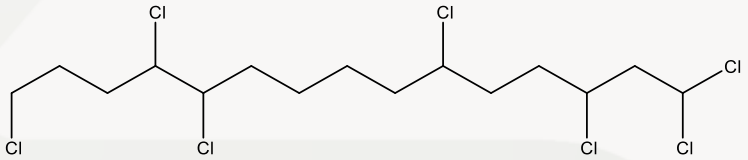
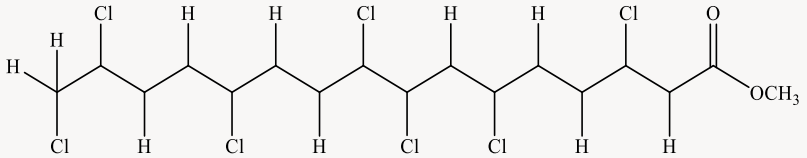
SECONDARY PLASTICIZER

Chlorinated Paraffins (CP52)



***Essebiochlor* 45 (HV)**



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ESSEBIOCHLOR HV – SECONDARY PLASTICIZER

- It is NOT chlorinated paraffin
- It is chlorinated ester of bio-origin and biodegradable
- It has plasticizing efficiency as traditional chlorinated paraffin
- It is more compatible than CP with PVC
- There is low risk of migration in combination with primary plastici
- Much less volatile than CP in plasticized PVC compounds
- It is flame retardant
- Its thermal stability is similar to CP52 (but slightly lower)
- It is REACH registered and accepted in any standard
- It is sustainable and cost competitive

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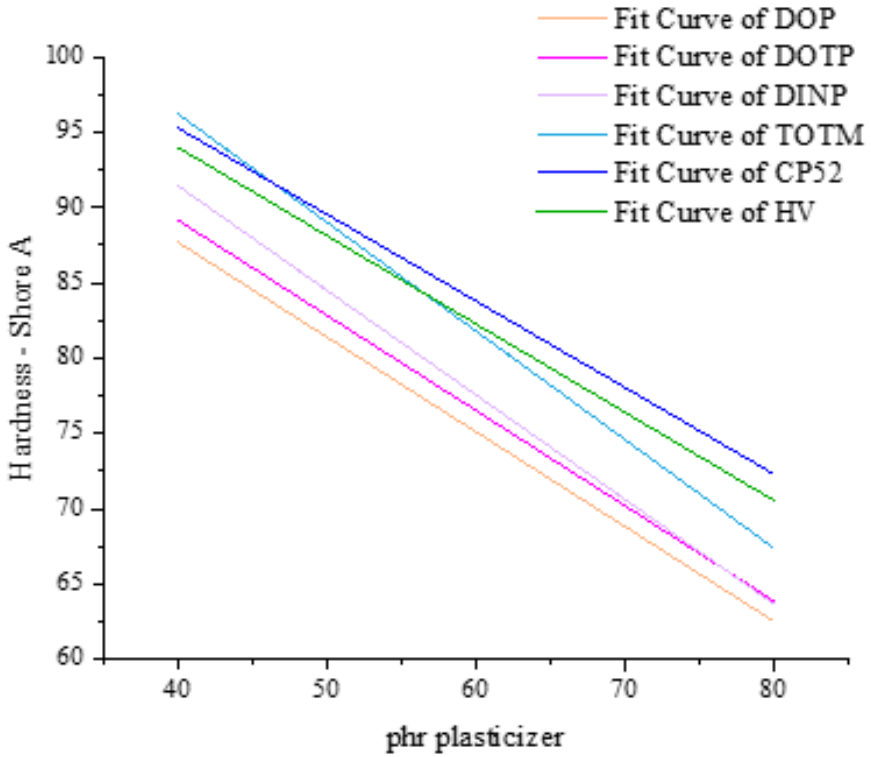
PLASTICIZER EFFICIENCY

The substitution factor (SF) is a fundamental parameter for evaluating the performance of a plasticizer. It allows quantification of a plasticizer's efficiency in relation to the Shore A hardness of a PVC compound.



DOP $y = 112.84 - 0.62\,x$

DOTP $y = 116.61 - 0.64\,x$

DINP $y = 117.34 - 0.67\,x$

TOTM $y = 125.30 - 0.72\,x$

CP52 $y = 118.27 - 0.57\,x$

HV $y = 117.43 - 0.59\,x$

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PLASTICIZER EFFICIENCY

$$Substitution\ factor\ (SF) = \frac{phr\ plasticizer}{phr\ DOP}$$

	Primary Plasticizer				Secondary Plasticizer	
	DOP	**DOTP**	**DINP**	**TOTM**	**CP52**	**HV**
Hardness 80 (phr plasticizer)	52,90	54,70	60,00	62,60	67,10	64,50
SF	1,00	1,03	1,10	1,17	1,26	1,22

DOP > DOTP > DINP > TOTM

HV > CP52

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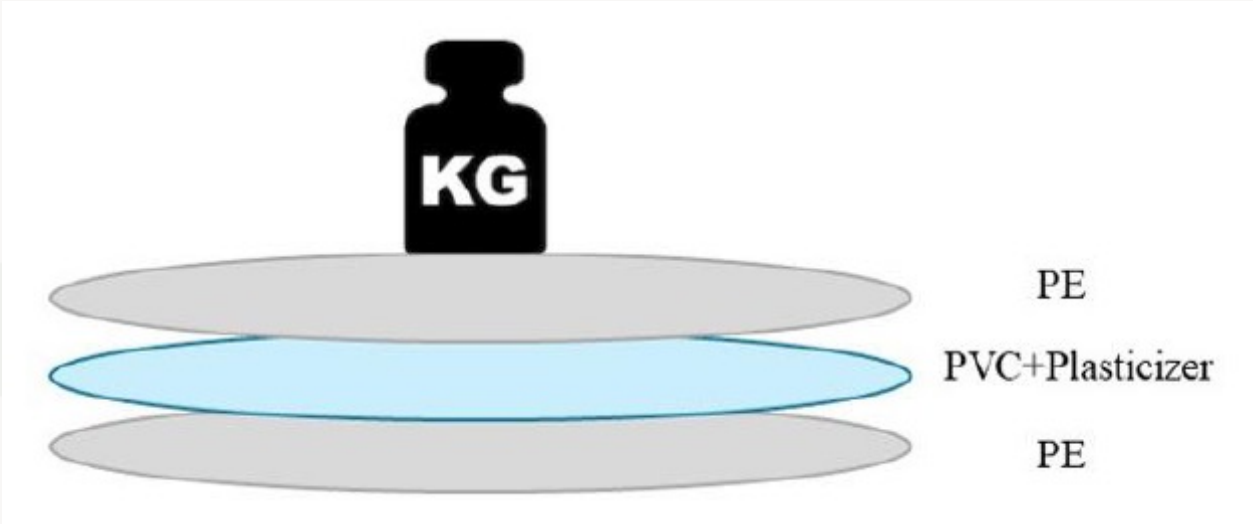
STUDY OF MIGRATION

In this work, a method was developed that consists of a PVC sample between two PE discs. The system is placed in an oven with a 2.5kg weight on top for one week at 70°C.



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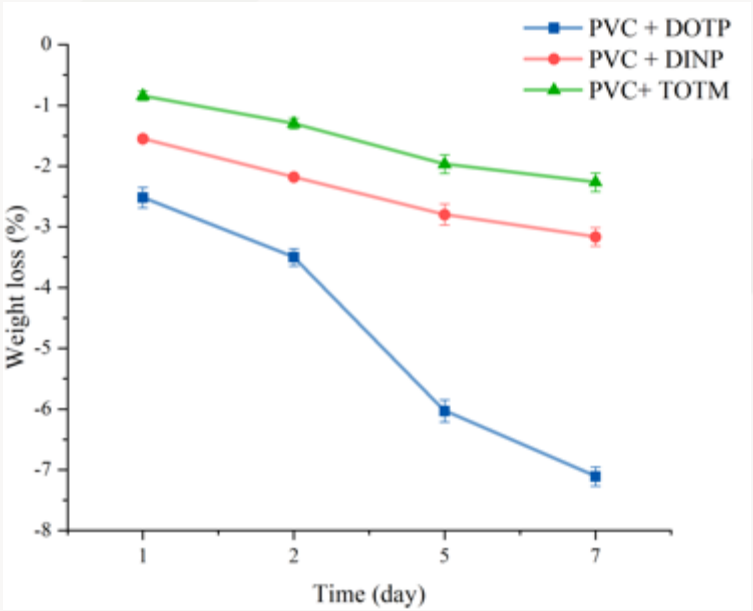
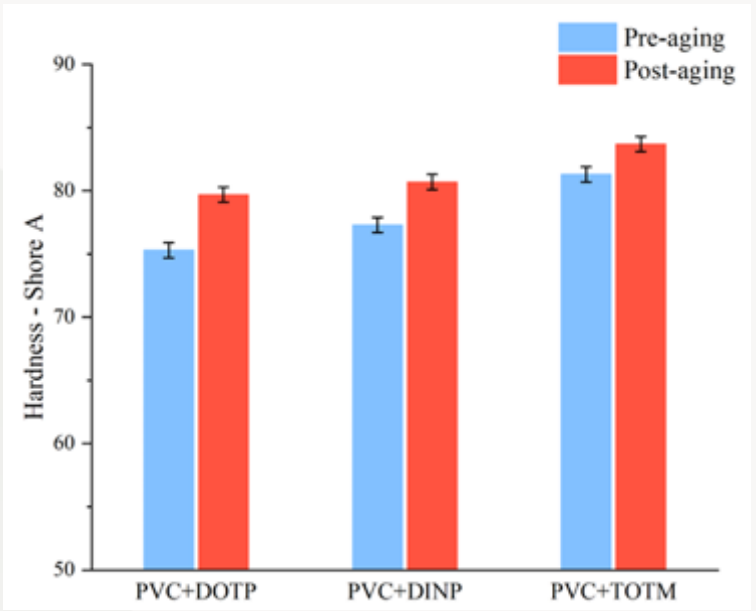
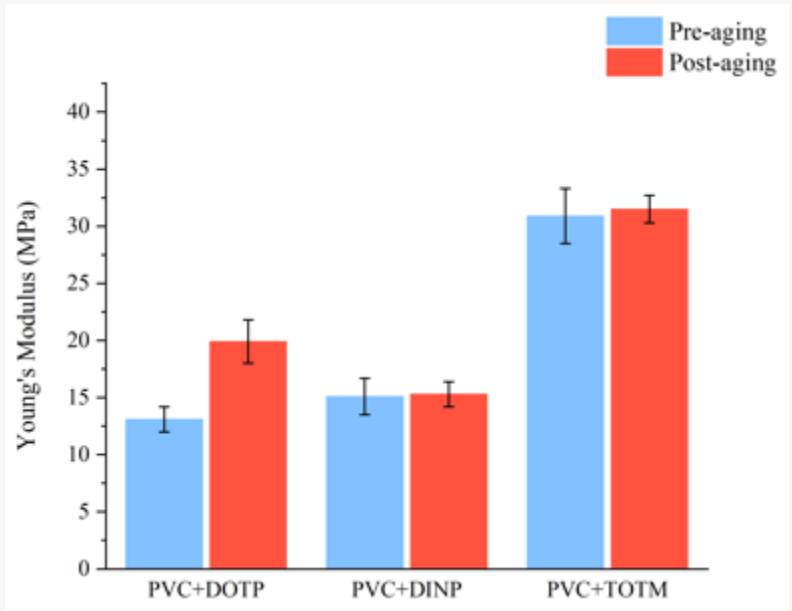
PRIMARY PLASTICIZER

	Formulation (phr)
PVC K70	100
Plasticizer	60
Stabilizer	3







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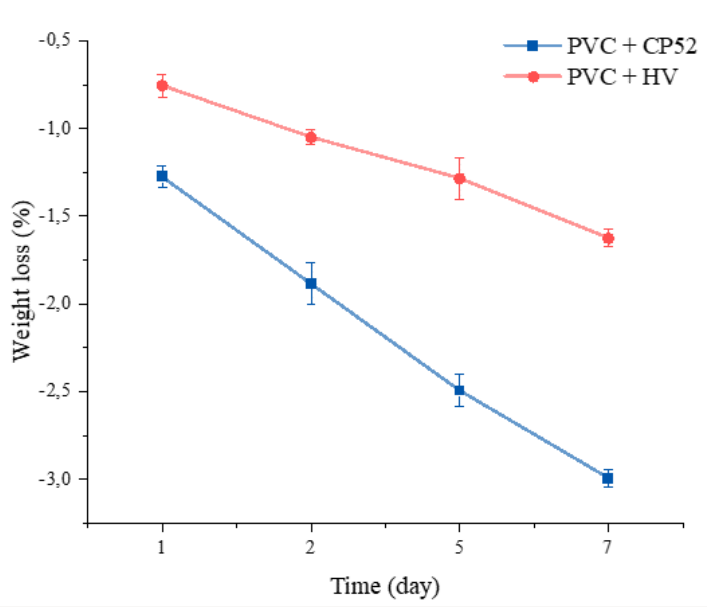
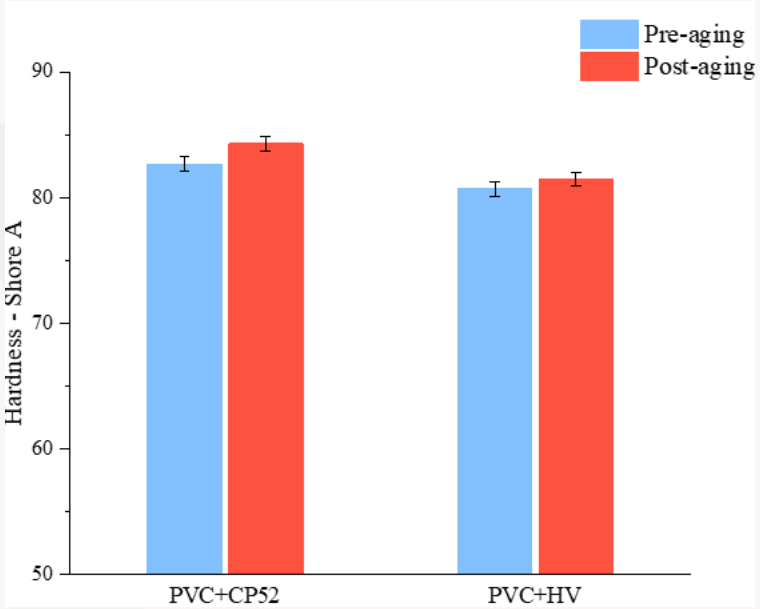
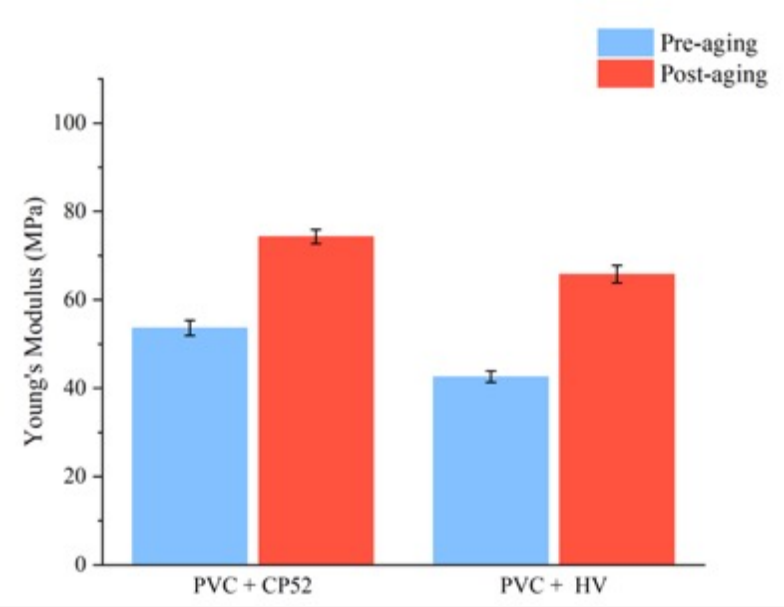
SECONDARY PLASTICIZER

	Formulation (phr)
PVC K70	100
Plasticizer	60
Stabilizer	3







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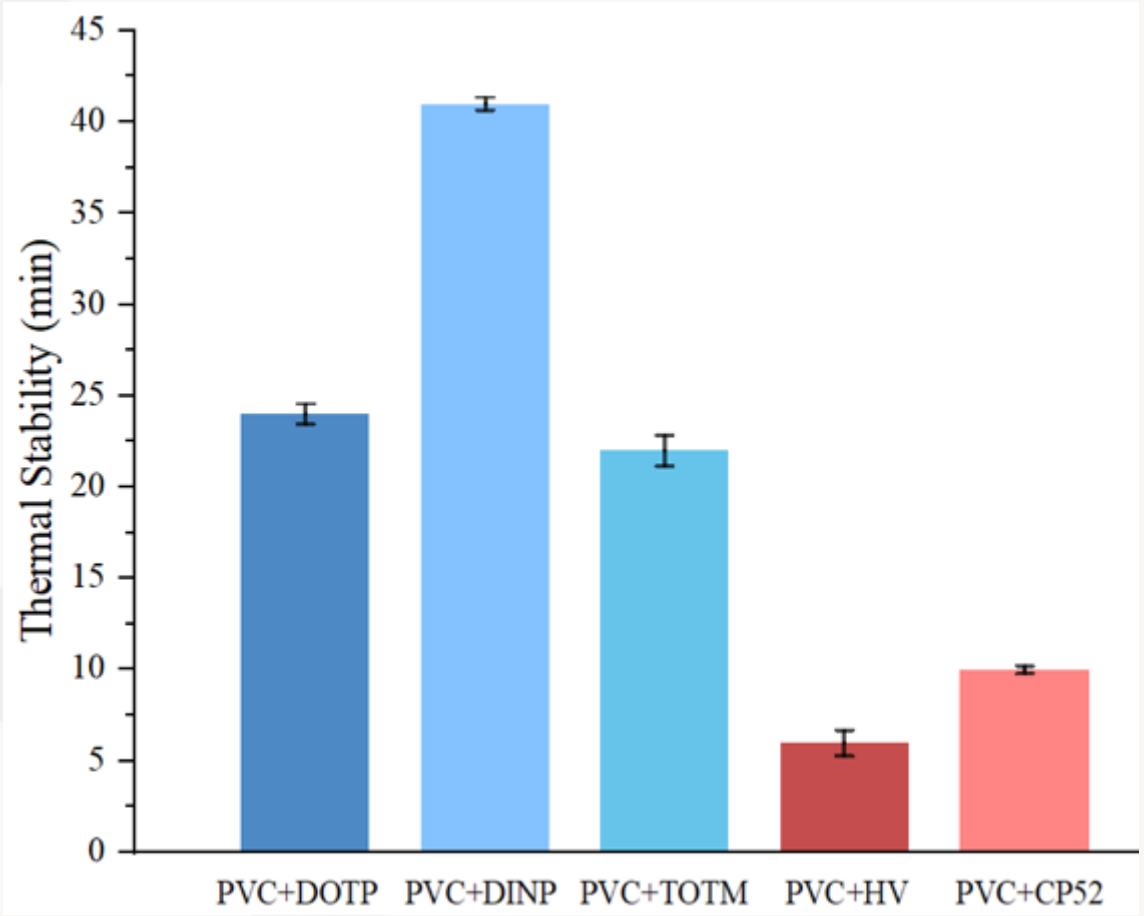
PRIMARY VS SECONDARY PLASTICIZERS



⇒ **Thermal stability: significantly lower for chlorinated plasticizers.**

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COMBINATION OF PRIMARY AND SECONDARY PLASTICIZERS

	DOTP + CP52 2:1	DOTP + HV 2:1	DINP + CP52 2:1	DINP + HV 2:1	TOTM + CP52 2:1	TOTM + HV 2:1
PVC K70	100	100	100	100	100	100
DOTP	40	40	-	-	-	-
DINP	-	-	40	40	-	-
TOTM	-	-	-	-	40	40
CP52	20	-	20	-	20	-
HV	-	20	-	20	-	20
Ca/Zn Stabilizer	3	3	3	3	3	3

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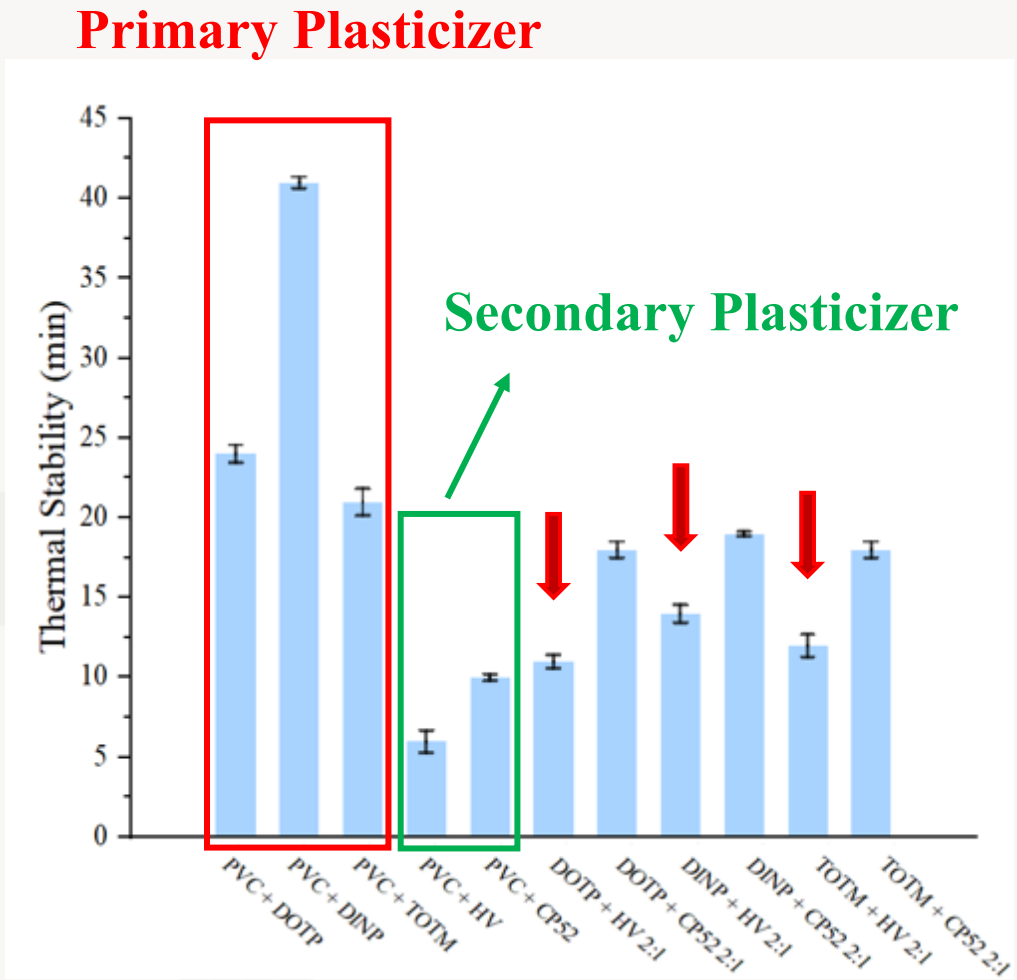
THERMAL STABILITY



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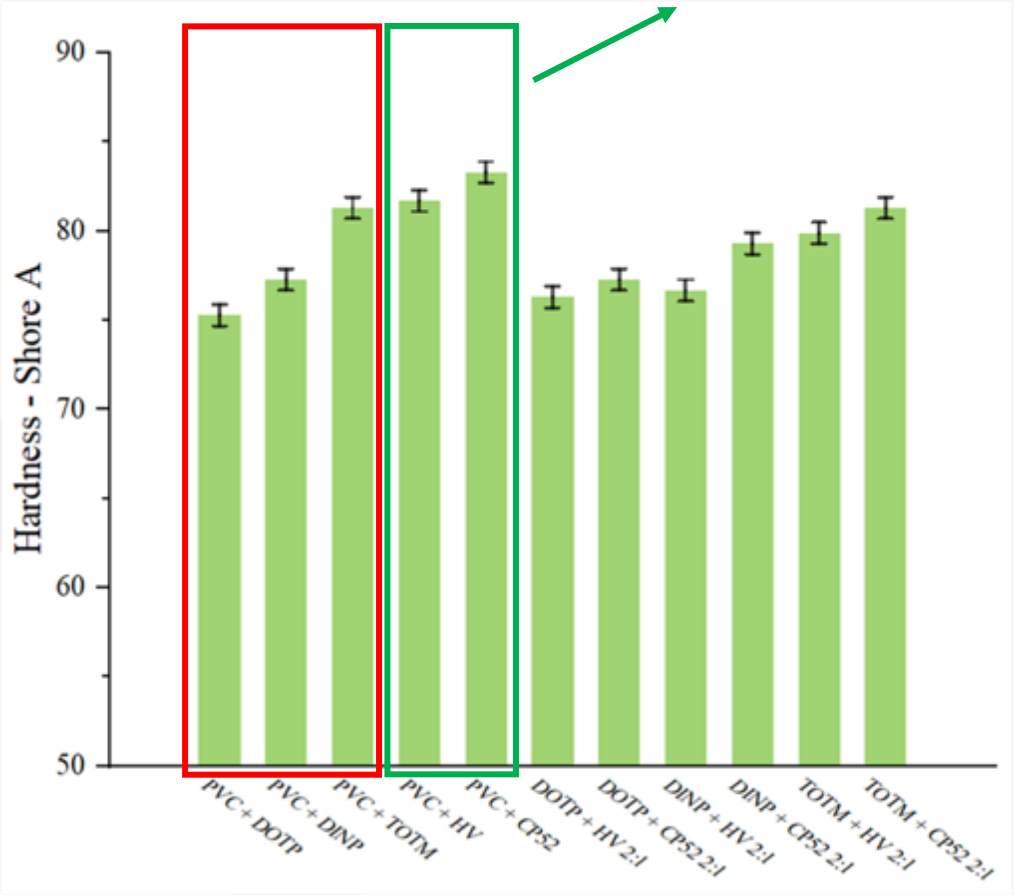
HARDNESS

Primary Plasticizer **Secondary Plasticizer**



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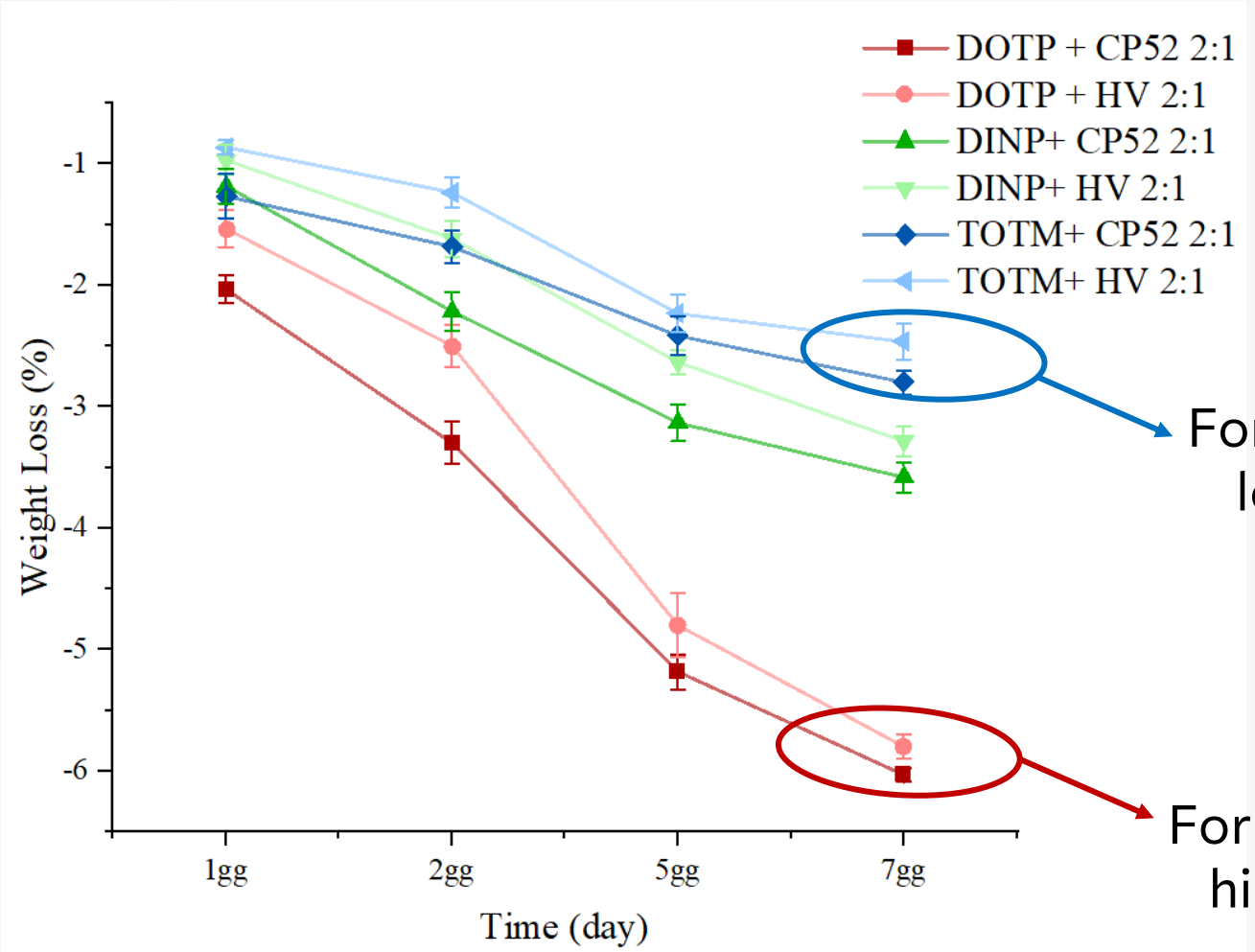
MIGRATION



Formulations with a lower migration rate

Formulations with a higher migration rate

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CHLORINATED PVC IN FLEXIBLE COMPOUNDS

Chlorination of PVC increases the chemical stability and fire resistance of the polymer.

Advantages

- Low cost
- Excellent chemical resistance
- Good thermal and mechanical properties
- High fire resistance
- **Very low smoke emission**

Disavantages vs PVC:

- Poor flexibility at low temperature
- Powder not absorbing plasticiser
- Lower thermal stability

	CPVC+ DINP
CPVC K67	100
DINP	60
Stabilizer	3

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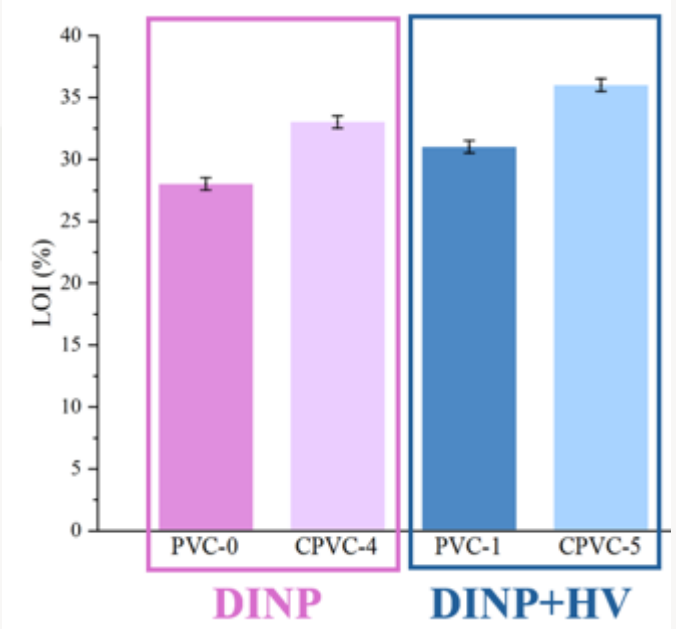
LOW SMOKE, FLAME RETARDANT C-PVC VS PVC

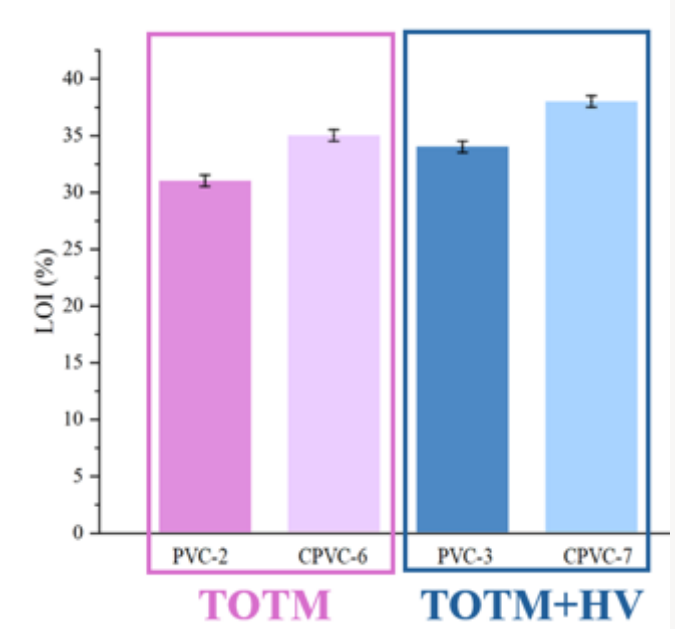
		PVC-0	PVC-1	PVC-2	PVC-3	CPVC-4	CPVC-5	CPVC-6	CPVC-7
Polymer	PVC K70	100	100	100	100	/	/	/	/
Polymer	CPVC	/	/	/	/	100	100	100	100
Plasticizer	DINP	60	40	/	/	60	40	/	/
Plasticizer	TOTM	/	/	60	40	/	/	60	40
Plasticizer	HV	/	20	/	20	/	20	/	20
Filler	$CaCO_3$	40	40	40	40	40	40	40	40
FR and SS	$Mg(OH)_2$	40	40	40	40	40	40	40	40
FR synergist	Zinc Borate	4	4	4	4	6	6	6	6
Flame retardant	Sb_2O_3	2	2	2	2	/	/	/	/
Stabilizer	Ca/Zn	3	3	3	3	3	3	3	3

LIMITING OXYGEN INDEX (LOI)

With ATO	PVC-0	PVC-1	PVC-2	PVC-3
LOI (%)	28 ± 0,5	31 ± 0,5	31 ± 0,5	34 ± 0,5

ATO-FREE	CPVC-4	CPVC-5	CPVC-6	CPVC-7
LOI (%)	33 ± 0,5	36 ± 0,5	35 ± 0,5	38 ± 0,5





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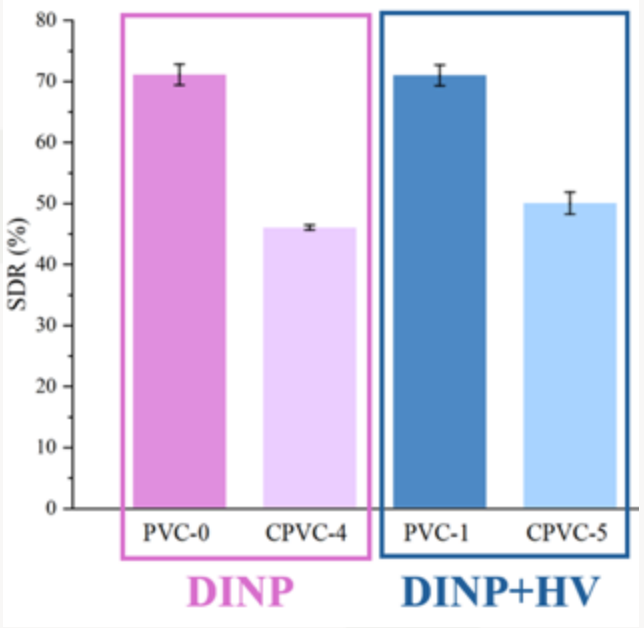
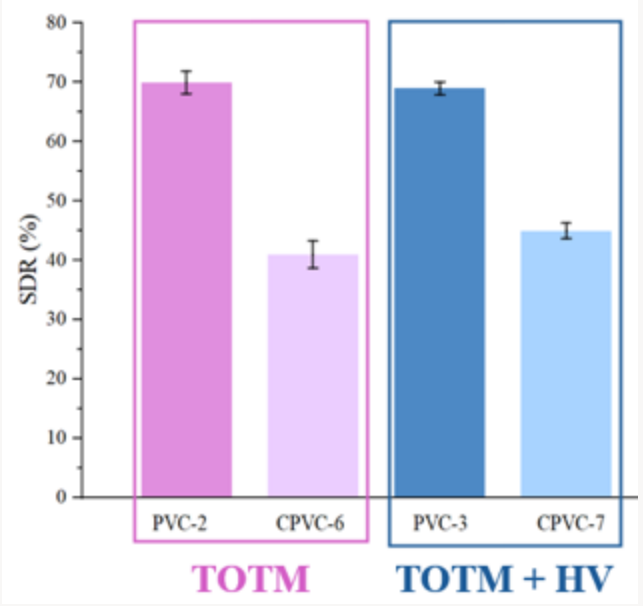
SMOKE DENSITY

	PVC-0	PVC-1	PVC-2	PVC-3
SDR (%)	71 ± 2	71 ± 1	70 ± 2	69 ± 2

	CPVC-4	CPVC-5	CPVC-6	CPVC-7
SDR (%)	46 ± 2	50 ± 2	41 ± 1	45 ± 1





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CONCLUSIONS

- Essebiochlor is a sustainable, cost-competitive, flame-retardant, low volatility, secondary bio-plasticiser for PVC compounds.
- Migration rate of primary plasticizers: DOTP >> DINP > TOTM
- Migration rate of secondary plasticizers: CP52 > <Essebiochlor HV
- The TOTM+HV 2:1 formulation has the highest resistance to migration
- The C-PVC formulation with TOTM+HV 2:1 has **excellent fire resistancy without ATO** (LOI=38%), **very low smoke emission** (SDR=45%) and **no migration issues**.

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ONGOING R&D ACTIVITIES OF IPOOL IN PVC

- Application of micronized natural minerals in PVC compounds
- Development of cost competitive FR PVC formulations without AT
- Introduction of hyper-chlorinated organic compounds as additive o

For a new life of PVC: sustainable, safe, low smoke, flame retardant

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THANK YOU

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pvc4cables@pvc4cables.org