Nano Innovation 2016
Rome, 20-23 September
Conference & Exhibition

INCORPORATION OF NATURAL COMPOUNDS INTO POLYMERIC MATRIX: DEVELOPMENT OF ANTIMICROBIAL FILMS

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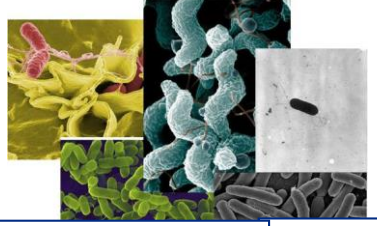
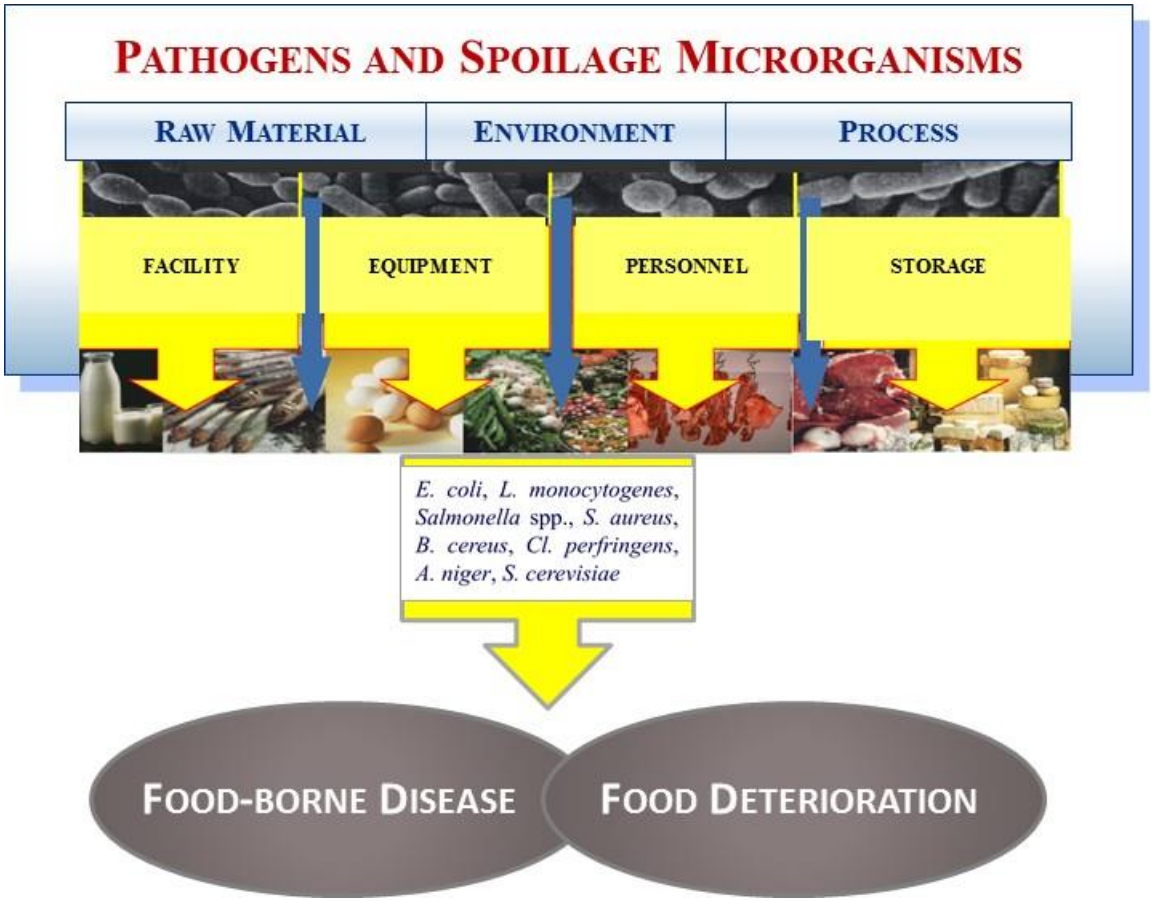
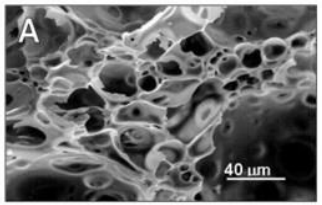
FOOD MICROBIAL CONTAMINATION

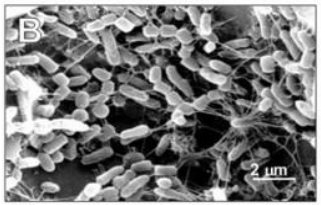


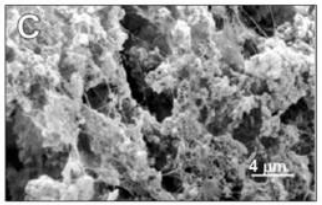
BACTERIA | YEASTS AND MOULDS

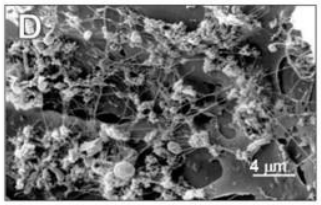


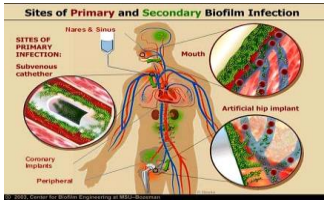
MICROBIAL BIOFILM

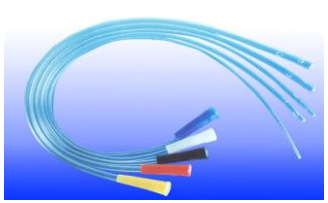




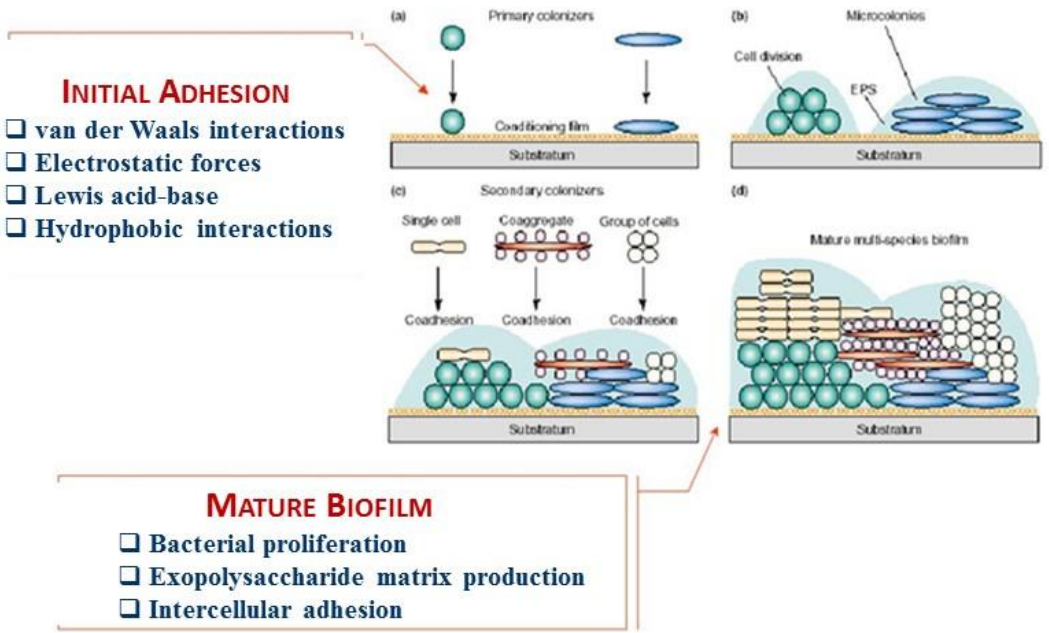




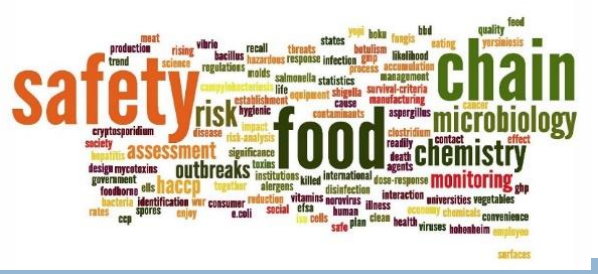




A BIOFILM CAN BE VERY DIFFICULT TO ERADICATE BECAUSE POOR SENSIBILITY TO CONVENTIONAL ANTIMICROBIAL AGENTS



ESSENTIAL OILS AND FOOD CONTROL



INCREASE IN CONSUMER DEMAND FOR MINIMALLY PROCESSED FOODS WITH REDUCED CHEMICAL ADDITIVES

PLANT ESSENTIAL OILS WITH A BROAD SPECTRUM OF ANTIMICROBIAL ACTIVITY

EFFICACY AGAINST PATHOGENS AND FOOD-BORNE MICROORGANISMS ALSO **IN FOOD MATRIX**

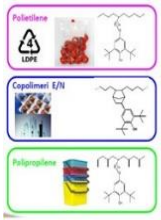
THEIR DIRECT ADDITION STILL ENCOUNTERS LIMITATIONS

- ❑EVAPORATION
- ❑HYDROPHOBICITY
- ❑SENSORIAL CHARACTERISTICS

DUE TO

New Antimicrobial Systems

Incorporation of Essential Oils into Polymeric Materials

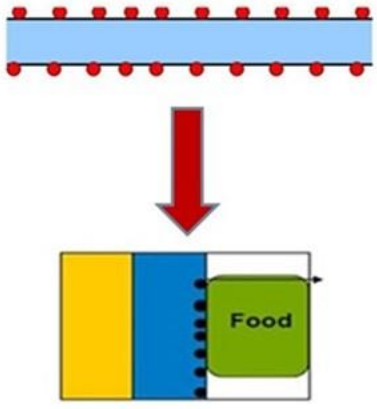


Synthetic Polymer	Natural Polymer
Low Density Polyethylene **(LDPE)**	Proteins, Starch, Alginate, Cellulose, Chitosan
High Density Polyethylene **(HDPE)**	
Polystirene **(PS)**	
Polypropylene **(PP)**	
Ethylene Vinyl Acetate **(EVA)**	

Active Packaging

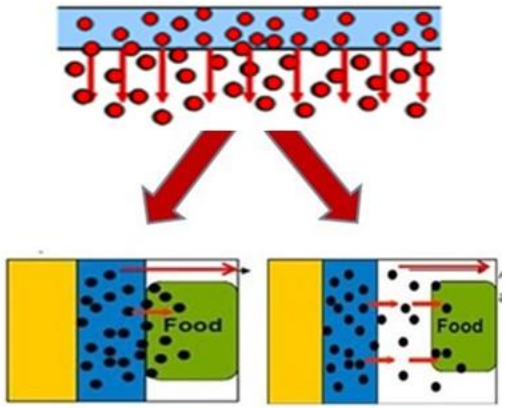
Active Packaging
Prolonged *Shelf Life*

Coating



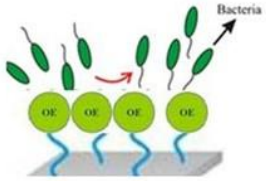
Activity by Contact

Incorporation

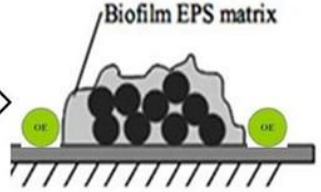


Activity by Release

Contamination Control



Biofilm Control



AIMS

Study on carvacrol and cinnamaldehyde polymeric films: mechanical properties, release kinetics and antibacterial and antibiofilm activities

A. Nostro · R. Scaffaro · M. D'Arrigo · L. Botta · A. Filocamo · A. Marino · G. Bisignano

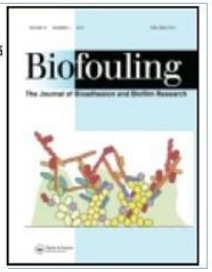
Applied and Microbiology Biotechnology

Biofouling, 2015
Vol. 31, No. 8, 639–649, http://dx.doi.org/10.1080/08927014.2015.1079703

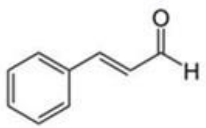
Taylor & Francis
Taylor & Francis Group

Effect of temperature on the release of carvacrol and cinnamaldehyde incorporated into polymeric systems to control growth and biofilms of *Escherichia coli* and *Staphylococcus aureus*

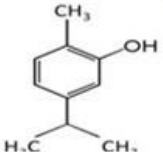
A. Nostro[a]*, R. Scaffaro[b], L. Botta[b], A. Filocamo[a], A. Marino[a] and G. Bisignano[a]



ANTIMICROBIAL AGENT

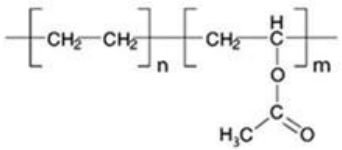


Cinnamaldehyde

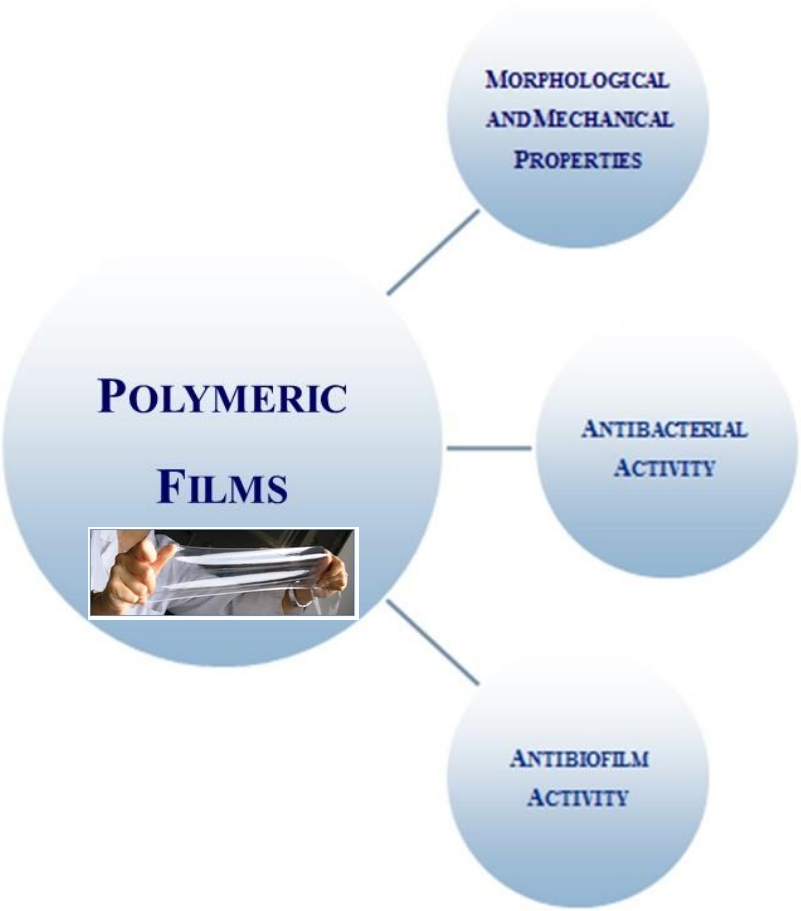


Carvacrol

POLYMERIC MATERIAL



Ethylene-vinyl-acetate (EVA14)



PREPARATION OF ANTIMICROBIAL POLYMERIC FILM

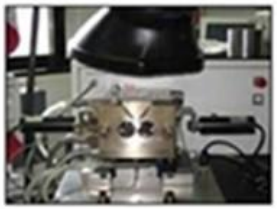
POLYMERIC MATERIAL

EVA containing 14% of vinyl acetate
Greenflex FC 45
Melt flow index 0.3 dg/min,
Melting T 93°C

ANTIMICROBIAL AGENT

CARVACROL
OR
CINNAMALDEHYDE
3.5 wt% -7wt%

MIXER IN A SINGLE-STEP PROCESS



T 120 °C
Rotational speed 64 rpm
Time ~ 1 min
Immersed in liquid nitrogen to reduce the evaporation

BATCH MIXER

COMPRESSION

T 120 °C
100 bar
Time ~ 2 min
Thickness 200 µm

Storage at 0 °C in vacuum packed plastic bags until their final use

POLYMERIC FILM

SURFACE AND MECHANICAL PROPERTIES


Dinanamometro


UV-Spettrofotometro


Angolo di Contatto


Microscopio Elettronico

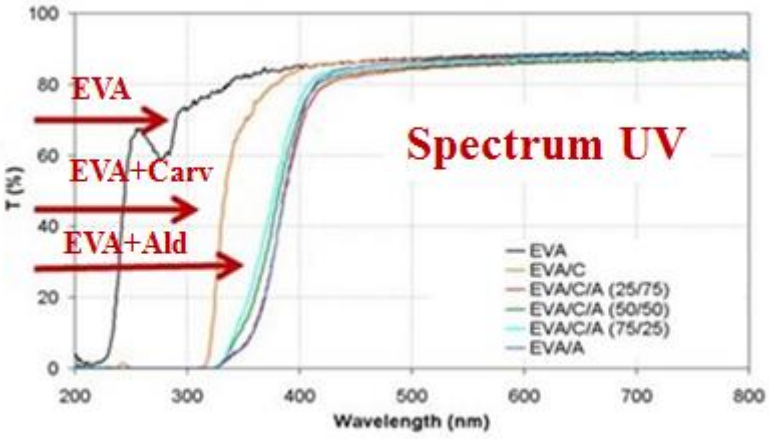
SEM

CONTROL CARV ALD

Samples 10×90 mm	E (Mpa)	TS (Mpa)	EB (%)	Contact Angle (°)
CONTROL	46.8 ± 1.9	24.8 ± 1.2	590 ± 20	92 ± 1.2
ALD	40.6 ± 1.5	17.1 ± 0.8	680 ± 28	79.4 ± 1.1
CARV	39.9 ± 1.6	16.4 ± 0.8	680 ± 30	75.3 ± 1.0

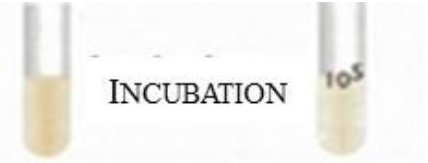
(E) Elastic modulus (TS) Tensile stress (EB) Elongation at break

Measured by a Dynamometer on rectangular shaped specimens (10×90 mm) cut off from films



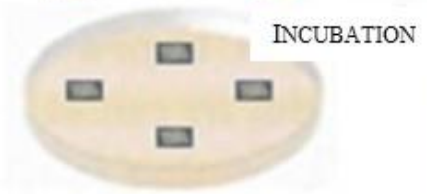
Time (h)	Release in water solution buffered			
	Carvacrol		Cinnamaldehyde	
	3.5 wt%	7 wt%	3.5 wt%	7 wt%
	mg/l			
0.5	1.57	3.36	0.41	0.61
1	1.83	3.88	0.53	0.65
2	2.21	4.73	0.62	0.68
4	3.27	6.54	0.75	0.79
16	13.30	28.24	10.00	12.80
24	13.91	29.56	10.36	13.00
48	14.20	30.10	12.50	16.60

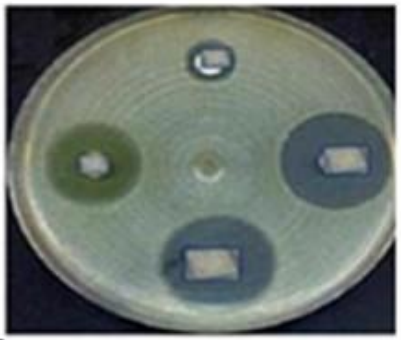
ANTIBACTERIAL ACTIVITY

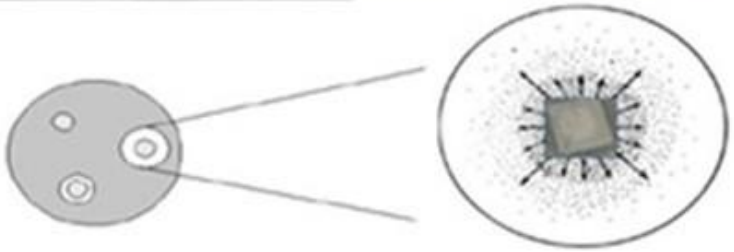


DISCS (1 cm ^{2})

DISC DIFFUSION TEST



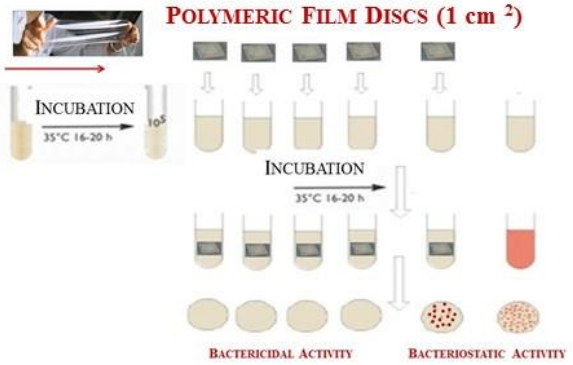


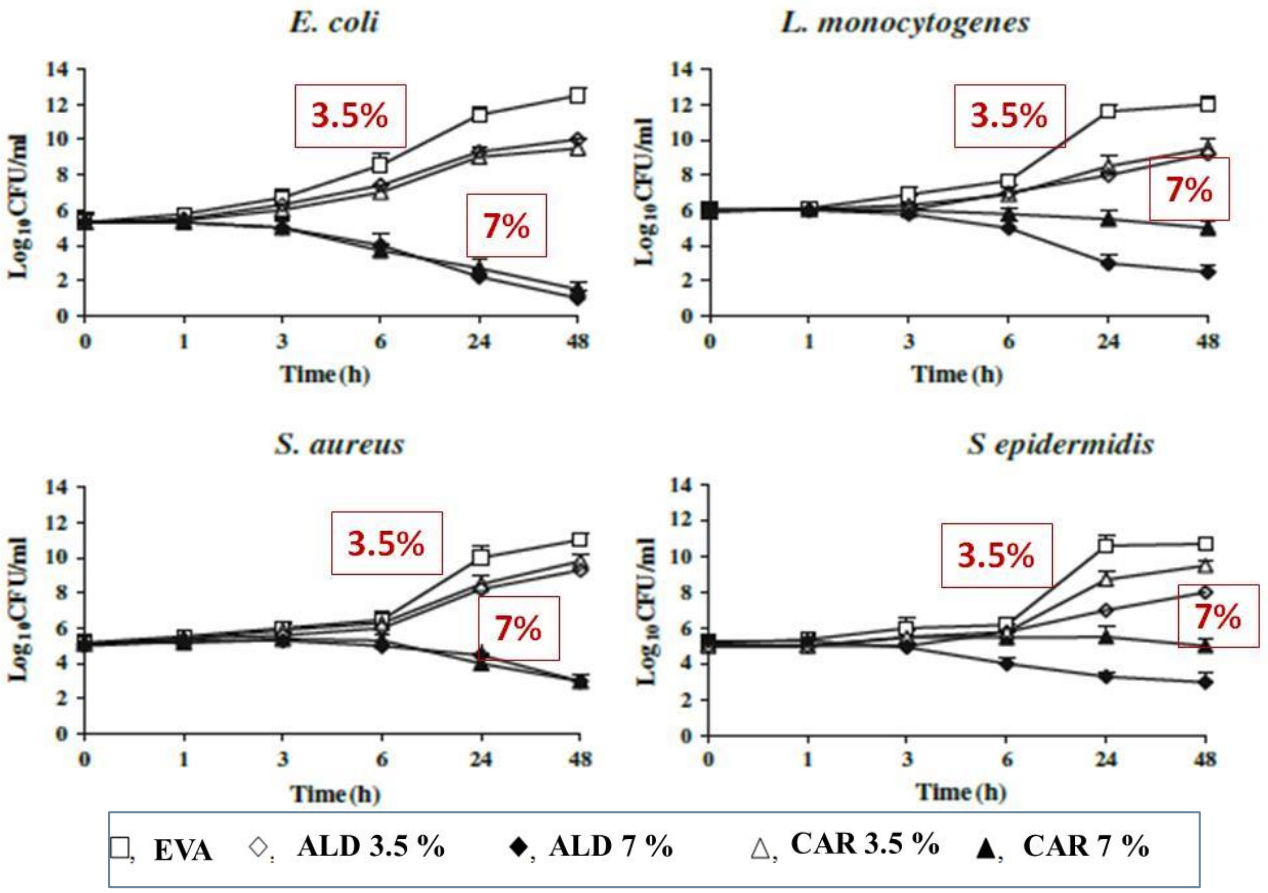


Samples		E. coli	L. monocytogenes	S.aureus	S.epidermidis
			Inibition alone (mm)		
EVA	-	-	-	-	-
EVA + ALD	7%	12	-	17	-
EVA +CARV	7%	14	15	15	17

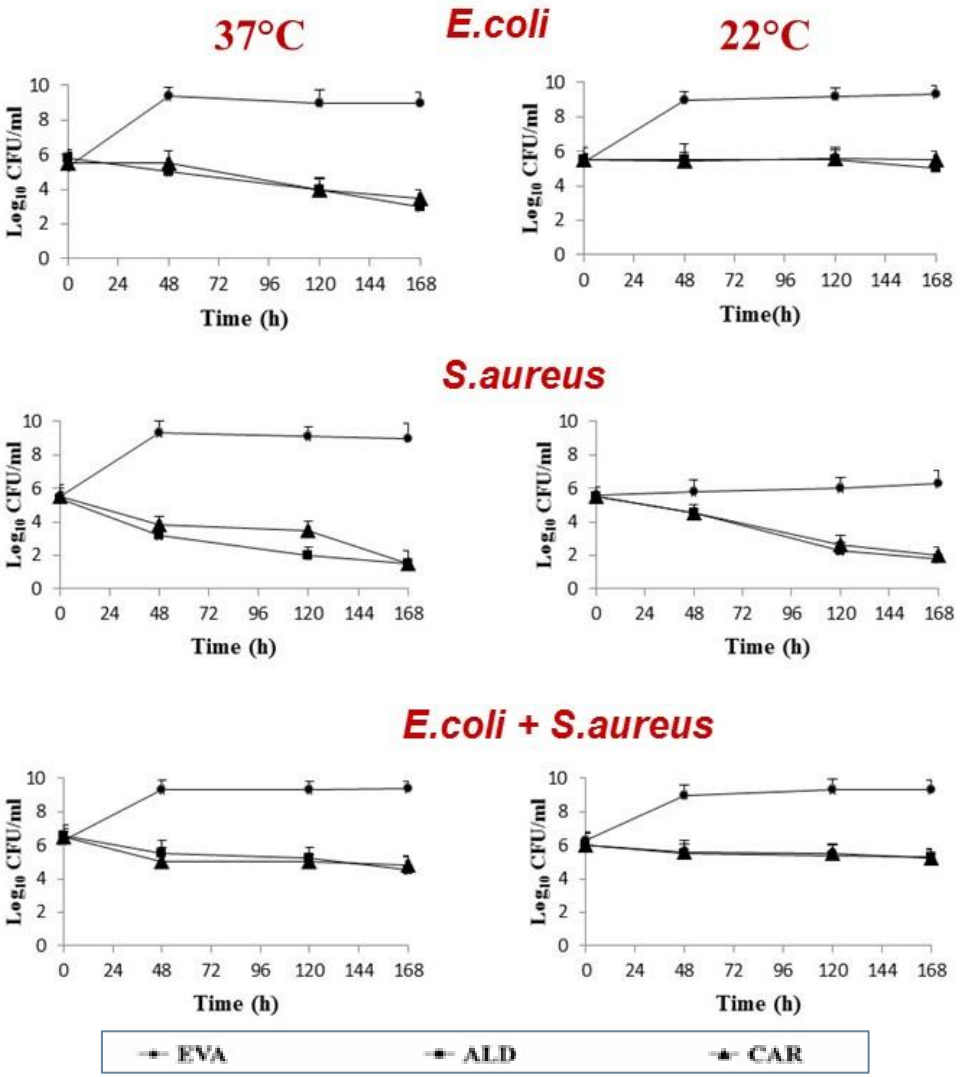
KILLING CURVES

BACTERICIDAL ACTIVITY





KILLING CURVES

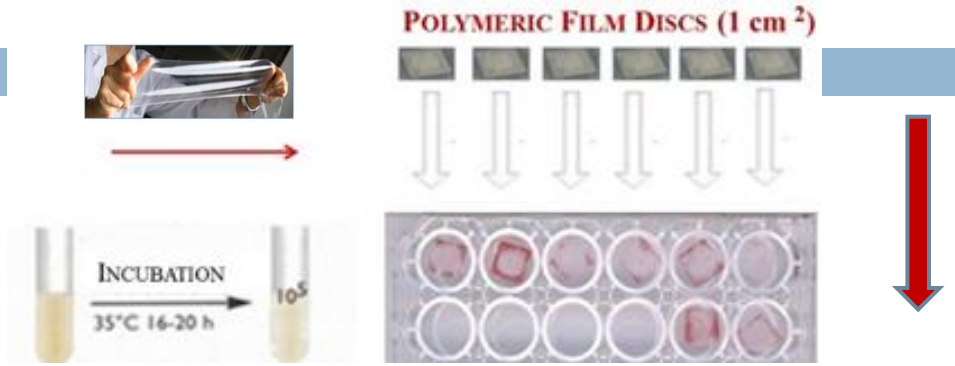


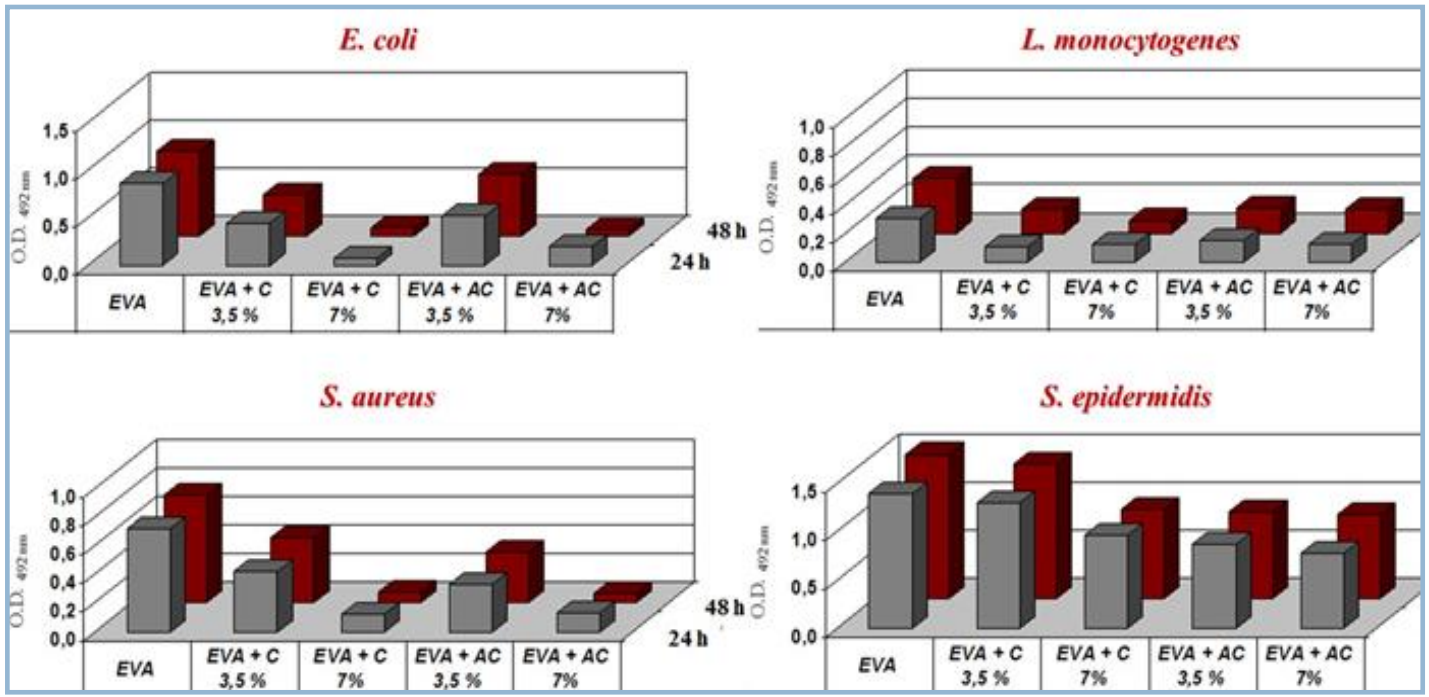
BACTERICIDAL ACTIVITY

4 °C **37 °C**

Sample	Temperature4°C 0 h	48 h	120 h	168 h	Temperature37°C 48 h
	Log_{10} CFU ml^{-1}				
EVA	5.56±0.55[a]	5.75±0.53[a]	5.69±0.38[a]	5.51±0.39[a]	9.24±1.04[a]
ALD	5.12±0.18[a]	5.00±0.25[a]	4.88±0.42[a]	4.55±0.43[a]	3.69±0.22[b]
CAR	5.52±0.32[a]	5.41±0.23[a]	5.56±0.45[a]	5.23±0.19[a]	3.82±0.54[b]

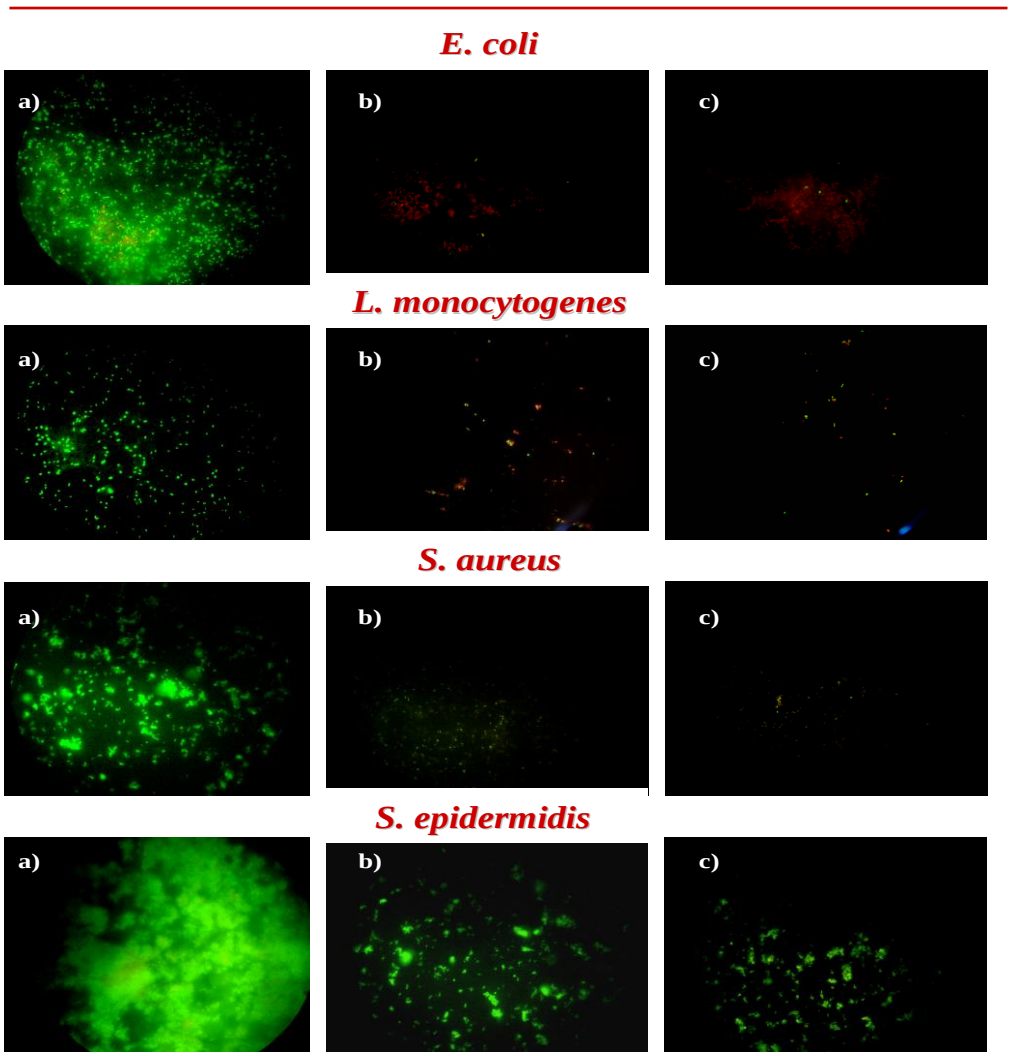
EFFICACY AGAINST BACTERIAL BIOFILM





Efficacy against Bacterial Biofilm

Fluorescence Microscopy Images - Live/dead staining



Biofilm Reduction

- Reduced Surface Hydrophobicity
- Bactericidal Activity

Presence of Viable Cells

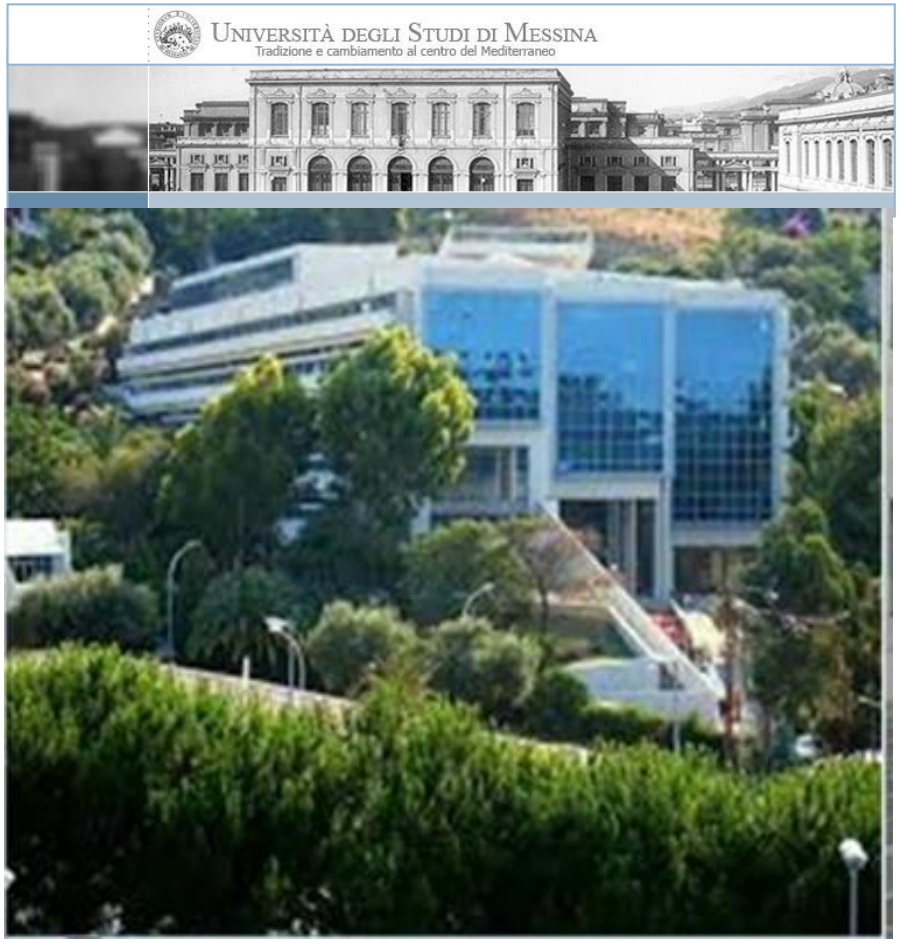
Presence of Dead Cells

CONCLUSION

CARVACROL
AND
CINNAMALDEHYDE
INCORPORATED INTO **EVA FILMS**
MAINTAIN
THEIR ANTIBACTERIAL AND
ANTIBIOFILM ACTIVITIES

- ⇨ Prolonged time and at different T values
- ⇨ Against single and mixed cultures
- ⇨ Either in Planktonic and Biofilm phase

THE RESULTS SUGGEST THEIR POTENTIAL ROLE FOR FUTURE APPLICATIONS AND OPEN UP NEW HORIZONS IN THE FOOD AND INDUSTRIAL AREAS



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Thank you For your Attention

Dipartimento di Scienze Chimiche, Biologiche, Farmaceutiche ed Ambientali
Università degli Studi di Messina