

Universidade do Minho
Escola de Ciências



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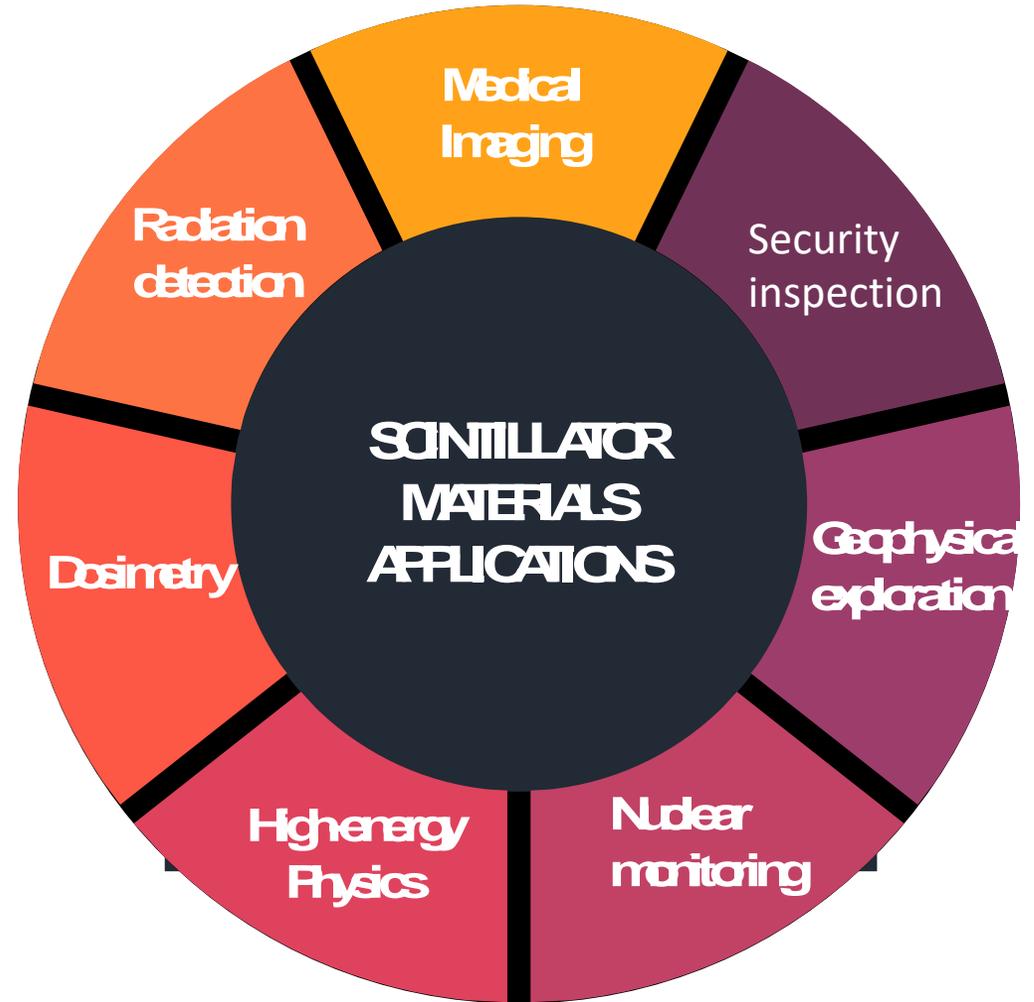
Essay MAP-fis

COMPOSITE SCINTILLATING NANOFIBERS BY ELECTROSPINNING FOR RADIATION DETECTION

Áureo Ucuajongo
id11632

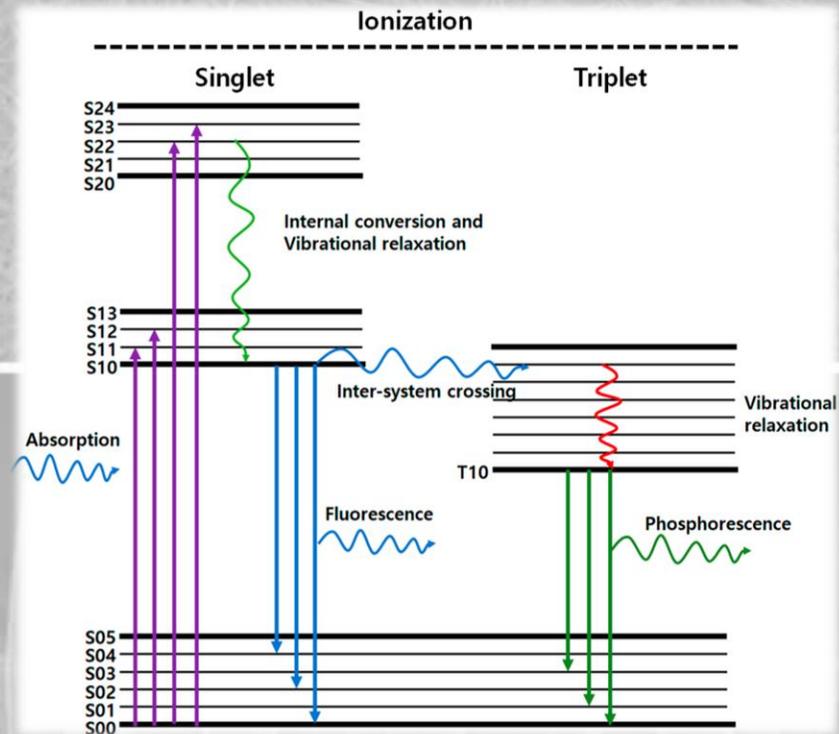
Introduction

Scintillator materials have found applications in various fields

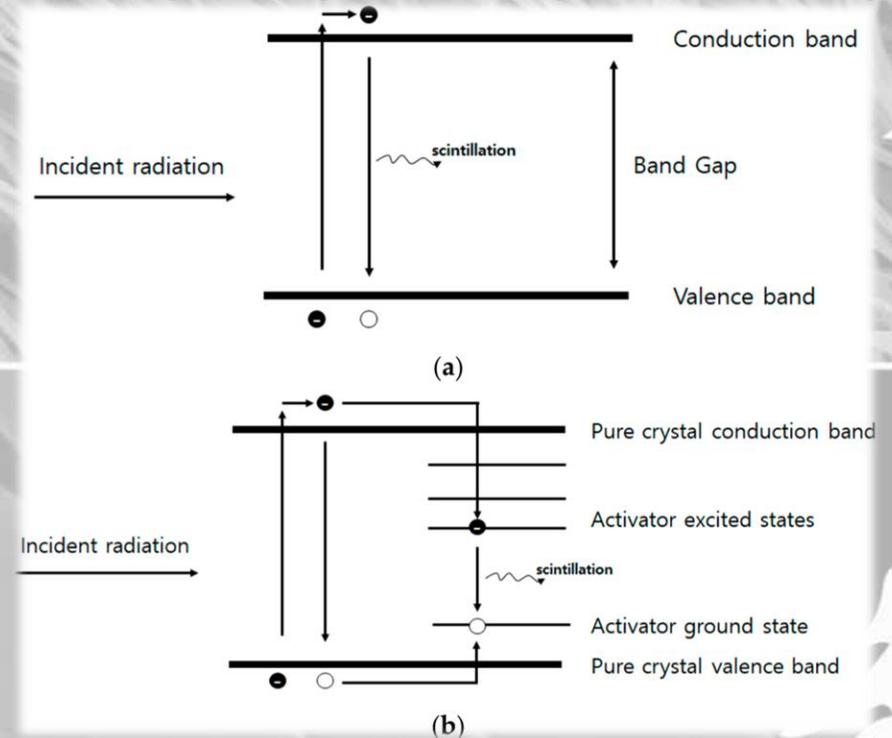


The Scintillation Process

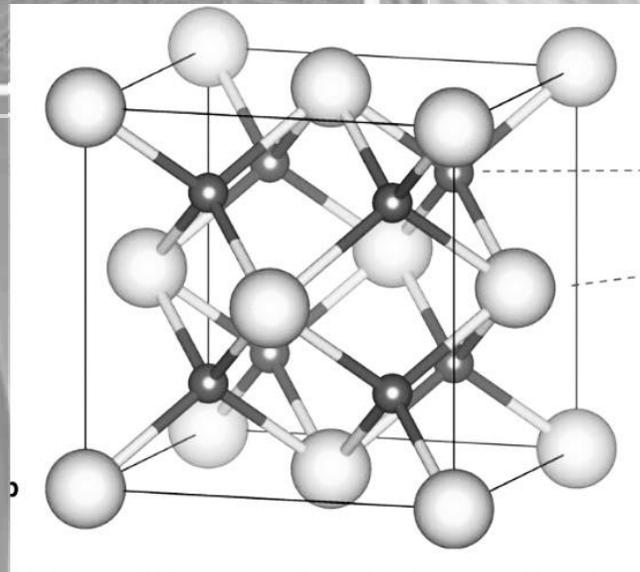
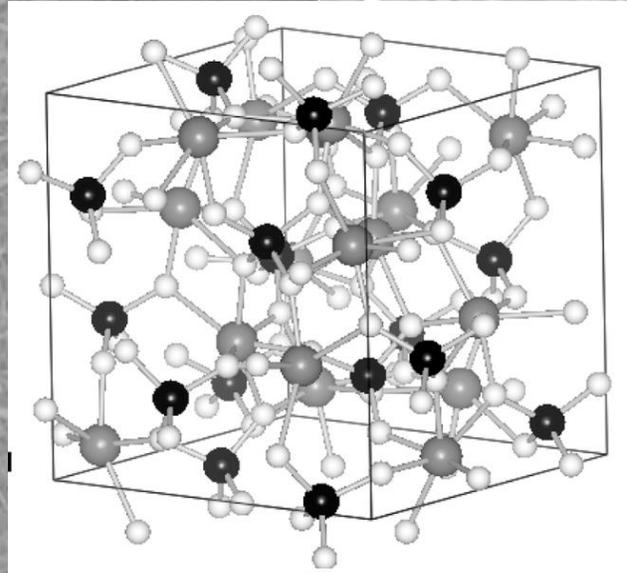
Scintillation mechanism in organic scintillator



Scintillation mechanism in inorganic scintillator



The most commercial scintillators



Shortcomings

Harsh Fabrication Conditions

High Costs

Sensitivity to Humidity

Sensitivity to Oxygen

Toxicity

Organic Scintillators

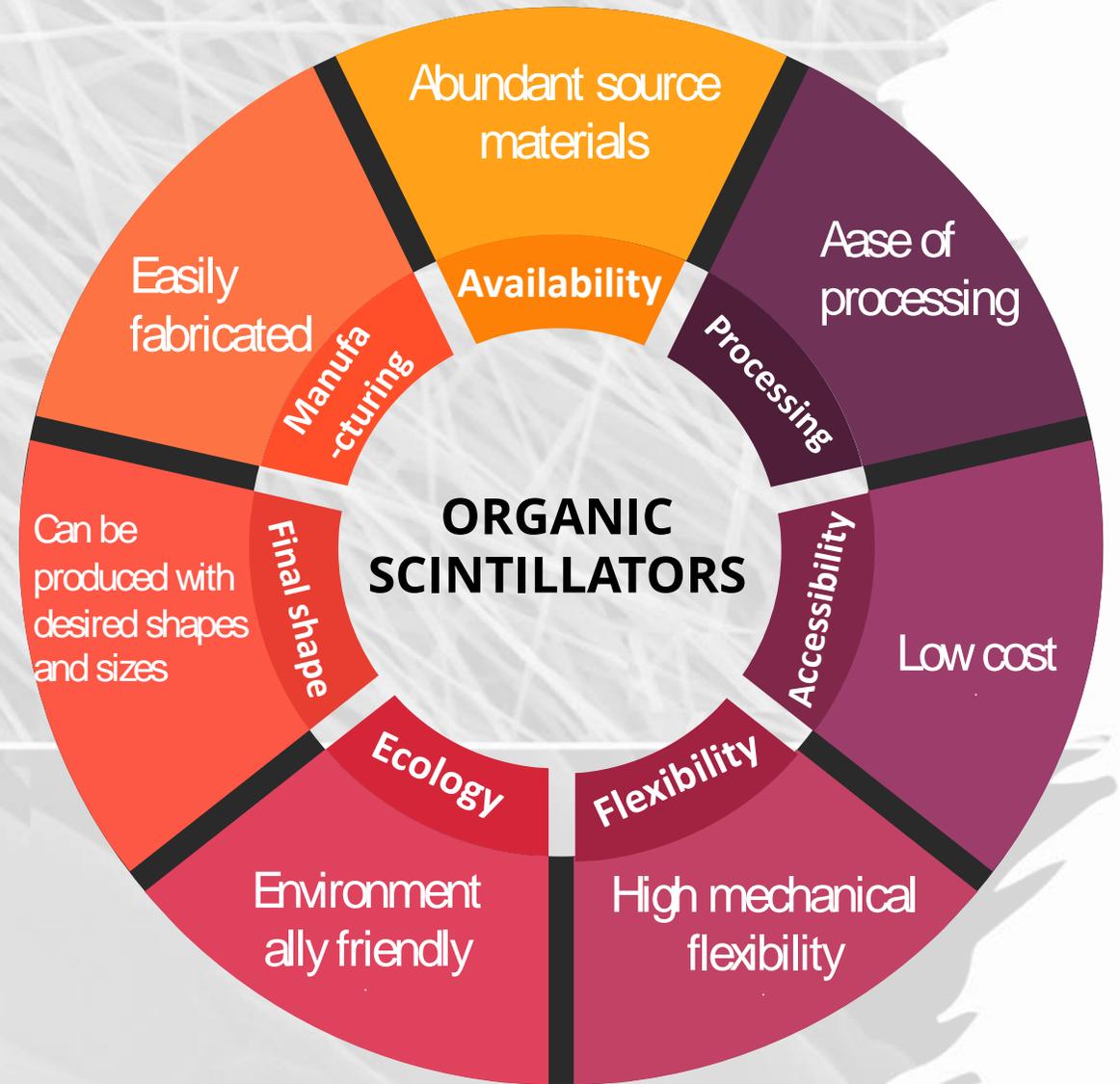
Examples

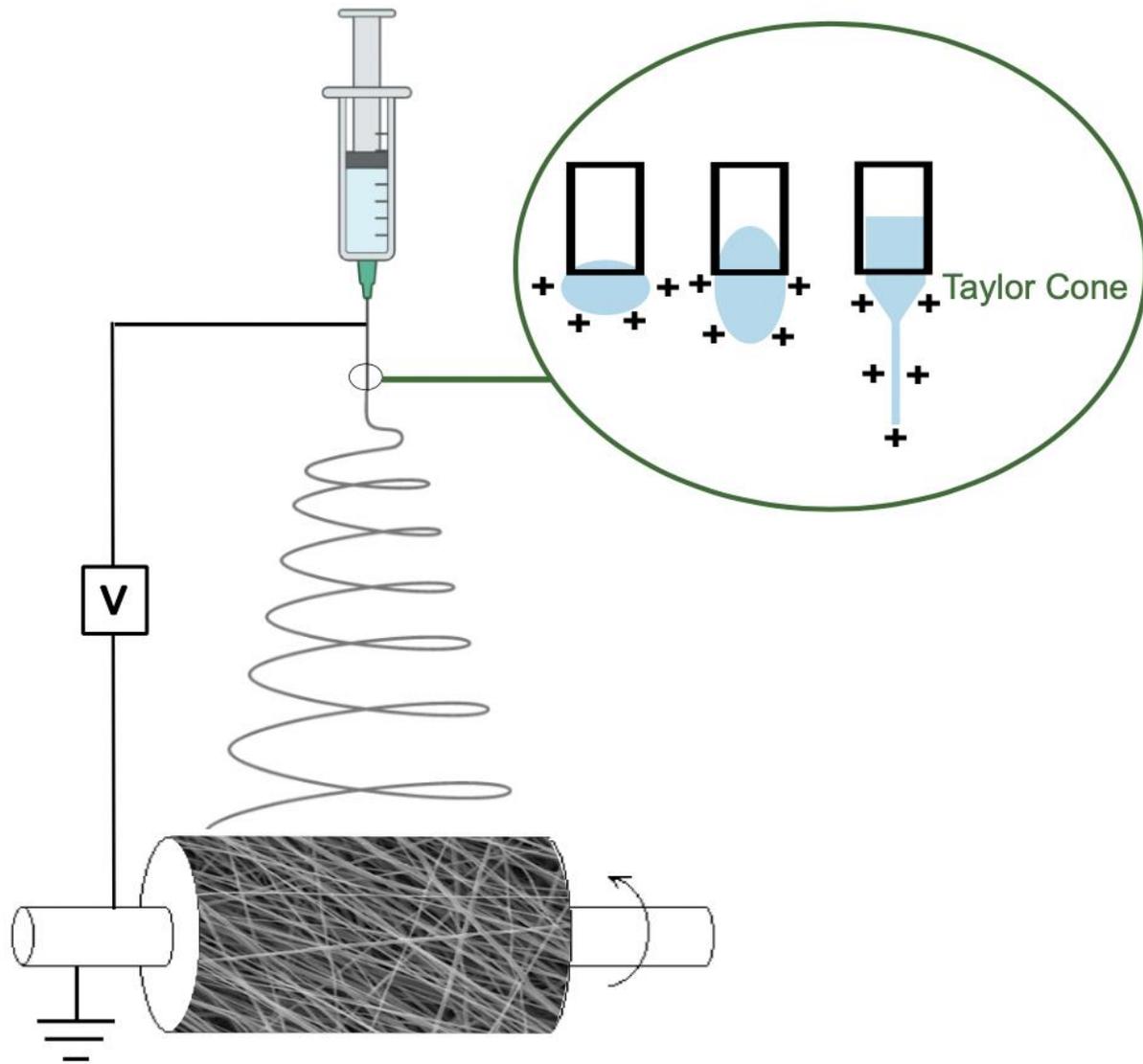
Antracene $C_{14}H_{10}$

Stilbene $C_{14}H_{12}$

1-phenyl-3-(2-oxazolyl)-benzoxazol
(POPOP)

1,4-bis[2-(5-phenyl-oxazolyl)]benzene
(POPOP)

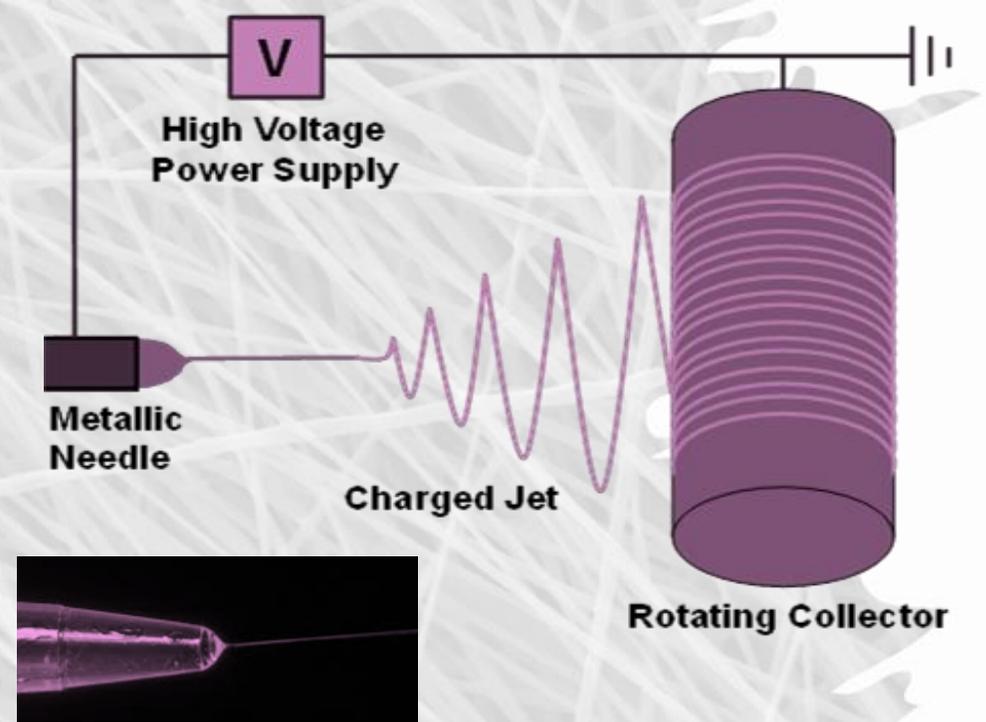
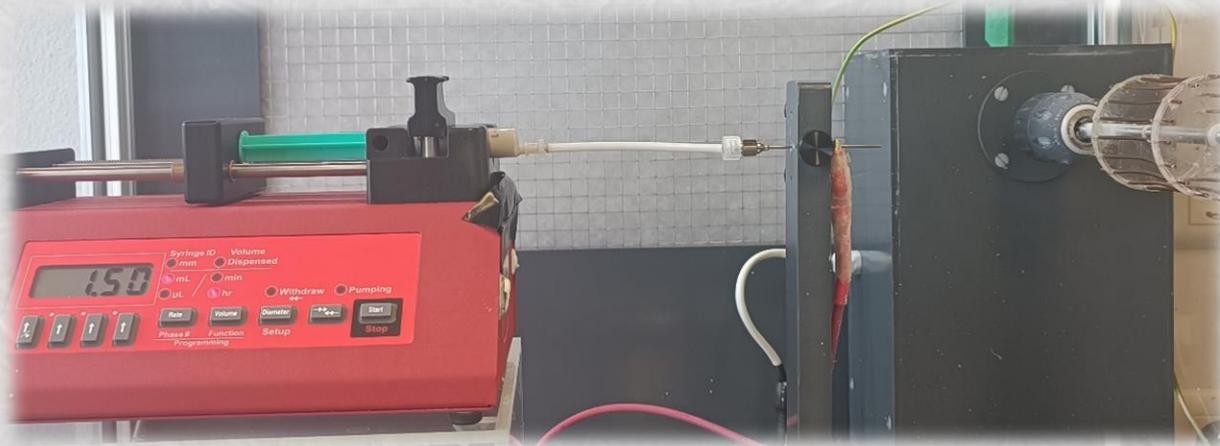




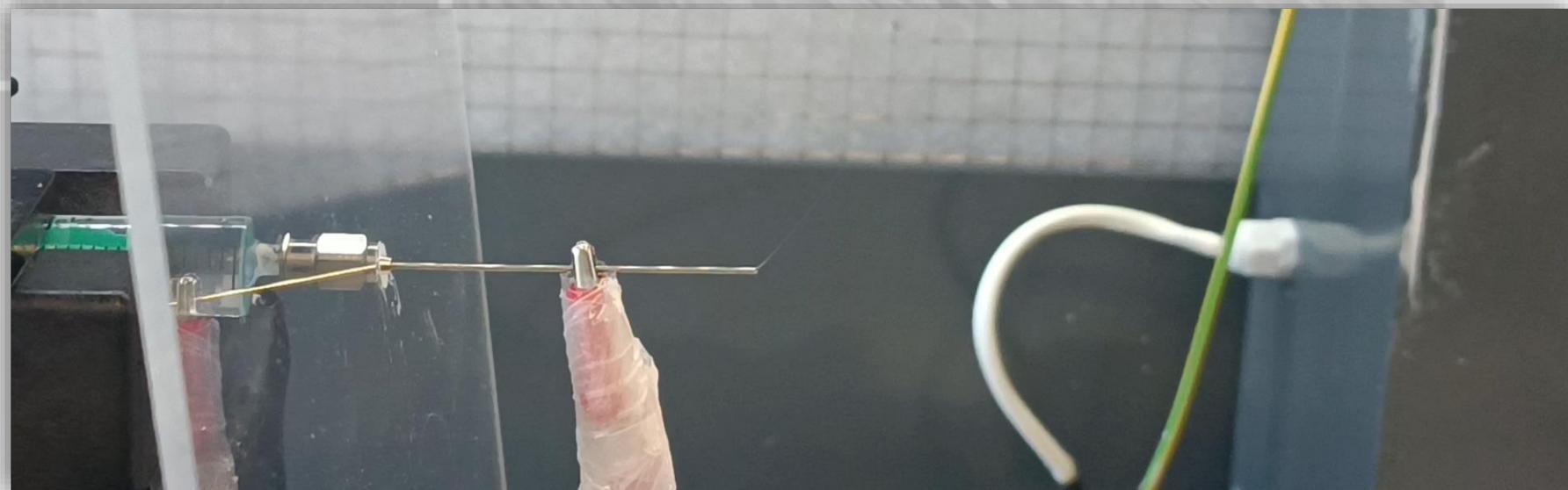
Electrospinning technique

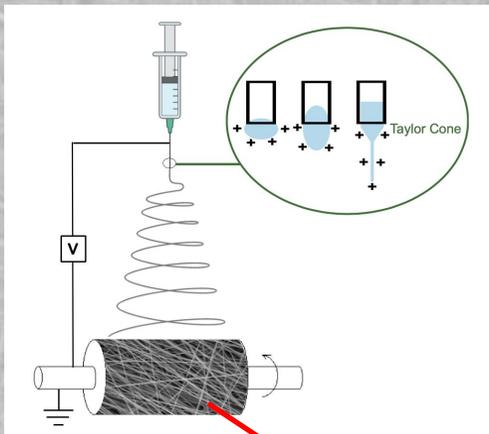
- 1- Capillary tube is filled with a polymer Solution
- 2- Voltage in the needle
- 3- Polymer droplet suspended from the needle
- 4- Taylor cone formation
- 5- Polymer solution ejected from the Taylor cone
- 6- Solvent evaporation
- 7- Fiber collected on the collector

Electrospinning



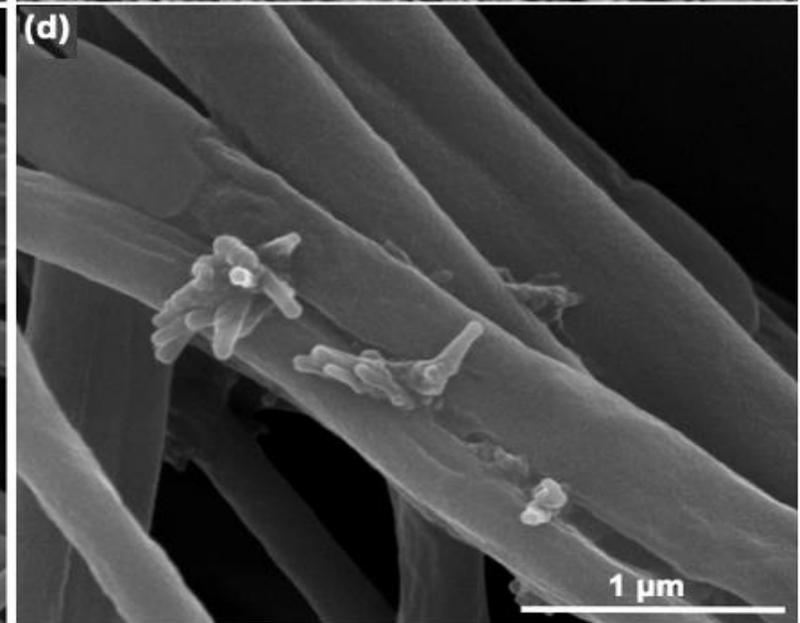
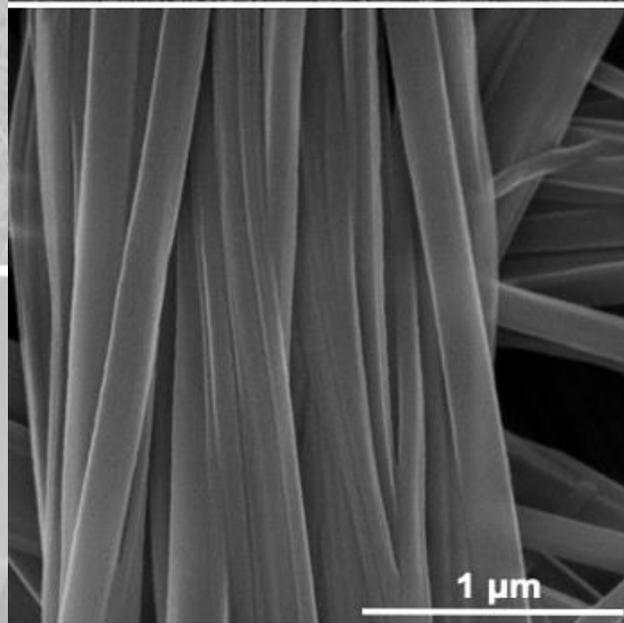
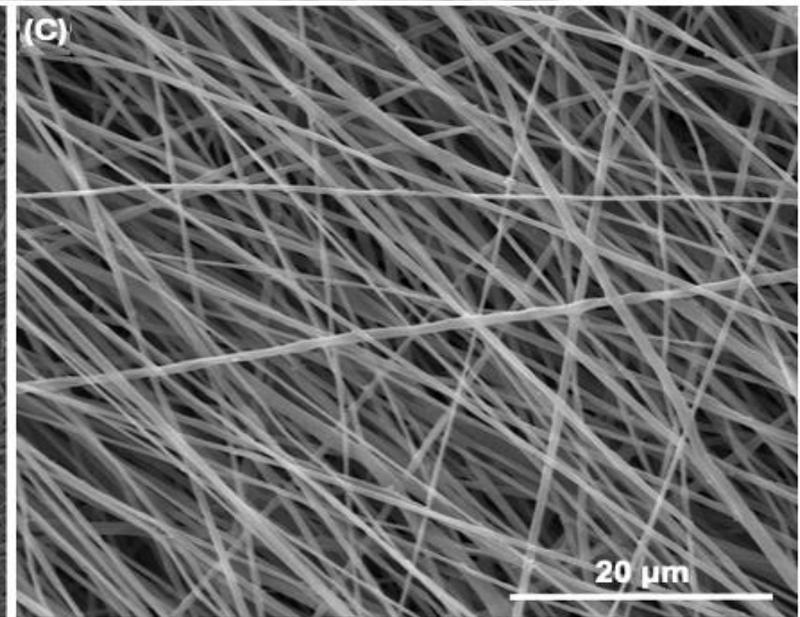
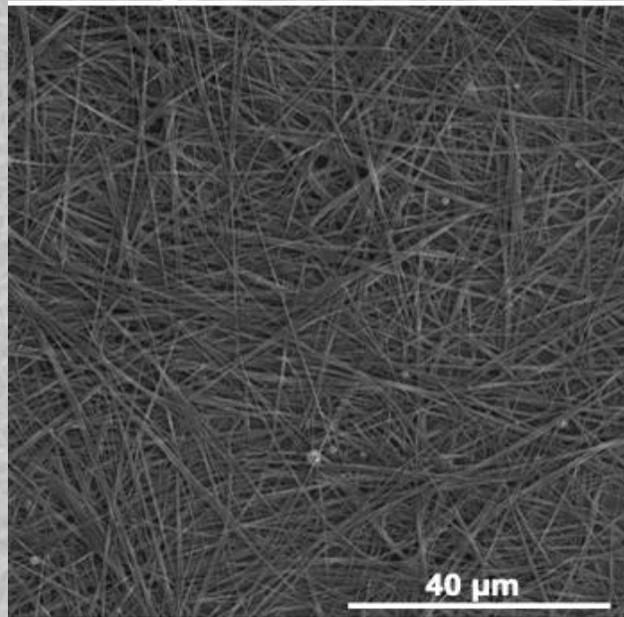
IN-FLIGHT, THE EMITTED JET IS STRETCHED, THE SOLVENT EVAPORATES AND THE FIBERS ARE FORMED, OCCURRING CRYSTALLIZATION OF THE CARRIER POLYMER AND OF THE ACTIVE MOLECULES INSIDE IT.





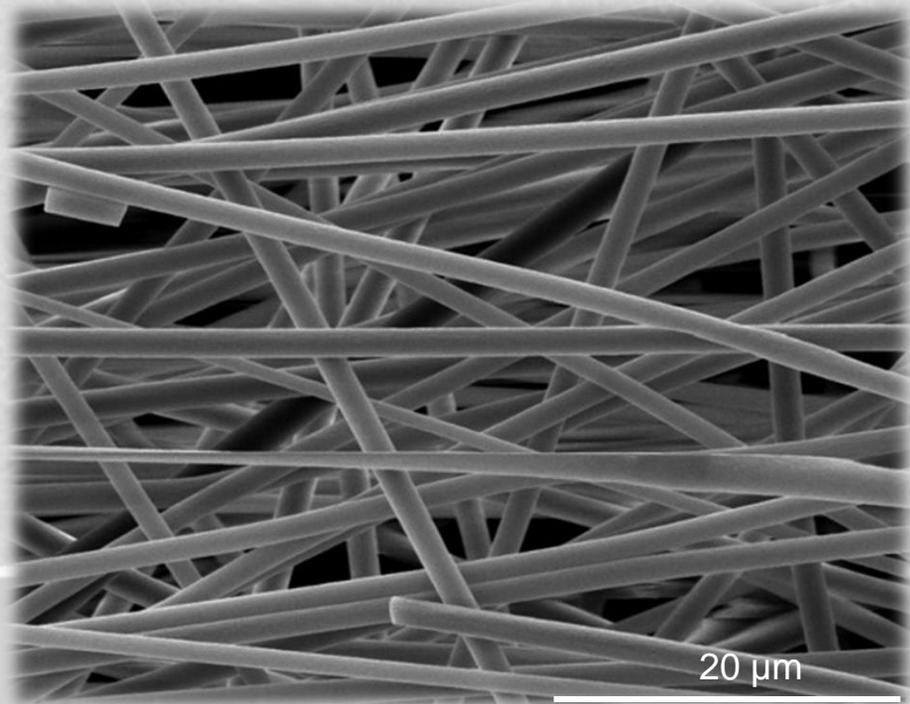
Electrospun nanofibers

SEM images of electrospun nanofibers

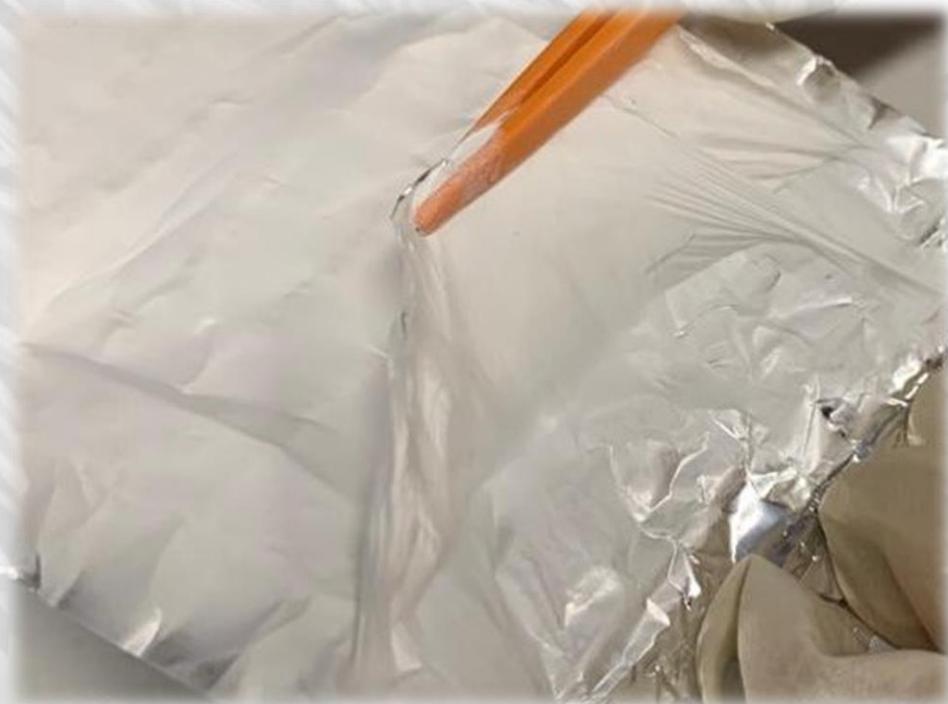


Nanofibers of Cyclo-L-Tryptophan-L-Tyrosine Dipeptide

Electrospinning



SEM image of the polymeric nanofibers

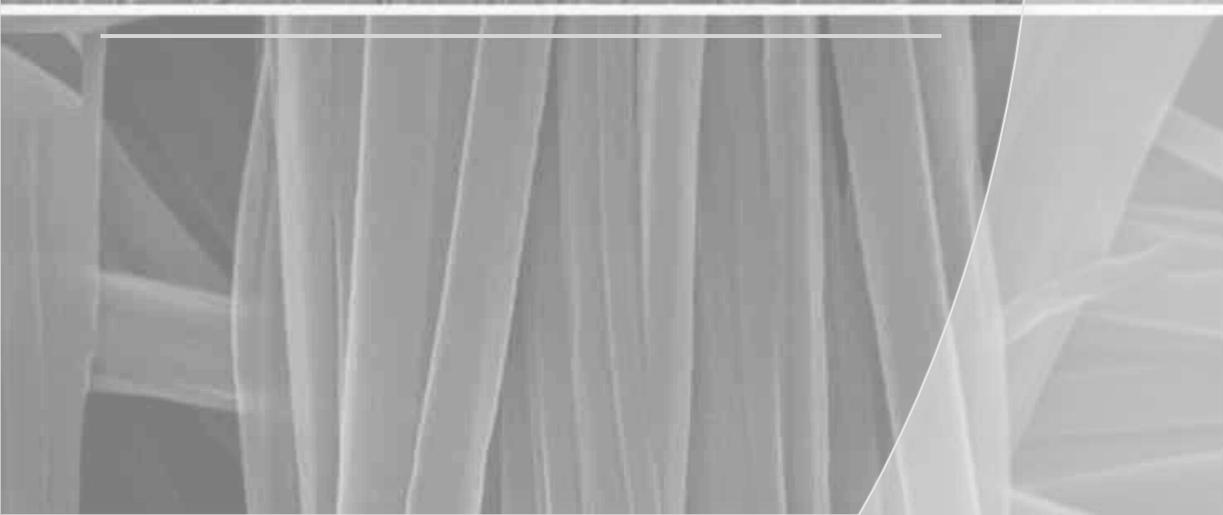


Fiber mat

Objectives

General objective

The project aims to develop nanofibers prepared by electrospinning for radiation detectors, focusing on a new generation of composite nanofiber mats embedded with inorganic nanoparticles and organic scintillation materials



Specific Objectives

1. **SYNTHESIS OF COMPOSITE NANOFIBERS EMBED WITH ORGANIC ACTIVE COMPOUNDS**
2. **SYSTEMATIC STUDY OF THE STRUCTURAL, CHEMICAL AND MORPHOLOGICAL PROPERTIES OF THE COMPOSITE NANOFIBERS**
3. **DETAILED STUDY OF THE SELF-ASSEMBLY PROPERTIES OF THE NANOPARTICLES AND ORGANIC SCINTILLATORS IN ELECTROSPUN NANOFIBERS**
4. **DETAILED CHARACTERIZATION OF THE STATIC AND FREQUENCY DEPENDENT ELECTRIC PROPERTIES AND RELAXATION BEHAVIOR OF THE FIBERS**
5. **SYSTEMATIC STUDY OF THE OPTICAL ABSORPTION AND PHOTOLUMINESCENCE OF THE COMPOSITE NANOFIBERS**
6. **SYSTEMATIC STUDY OF THE SCINTILLATION RESPONSE OF THE INDIVIDUAL COMPOUNDS AND COMPOSITE FIBERS**

Research work plan

TASK 2

STRUCTURAL, CHEMICAL,
MECHANICAL AND
THERMAL ANALYSIS

TASK 4

OPTICAL,
LUMINESCENT AND
NONLINEAR OPTICAL
PROPERTIES

TASK 1

SYNTHESIS of
RADIOLUMINESCENT
ELECTROSPUN SINGLE AND
COMPOSITE FIBERS

TASK 3

STUDY OF THE ELECTRIC
PROPERTIES OF THE
FIBERS

TASK 5

ASSESSMENT OF THE
SCINTILLATION
PROPERTIES OF THE
NANOFIBERS

Research work plan



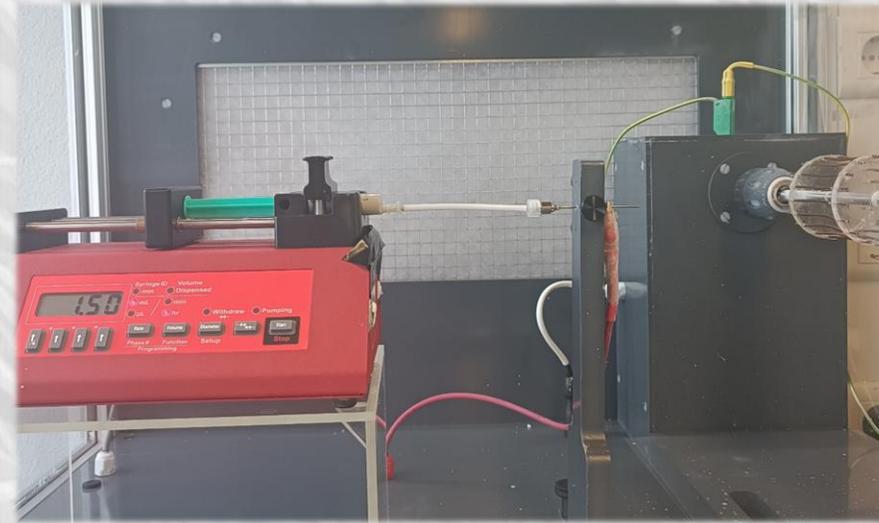
TASK 1
SYNTHESIS
RADIOLUMINESCENT
ELECTROSPUN SINGLE AND
COMPOSITE FIBERS

ORGANICS SCINTILLATOR:

- Stilbene,
- 1-fenil-3-(2-oxazolil)-benzoxazol (POP)
- 1,4-bis[2-(5-phenyl- oxazolyl)]benzene (POPOP)

X-RAY ABSORBERS:

- 4-N-carbazolyl-2,6-dichlorophenyl)bis- (2,4,6-trichlorophenyl)methyl
- 2,5-diphenyl-oxazole



THERMOPLASTIC POLYMERS: PET, PVC, PA11, PA66, and PCL

Research work plan

TASK 2

STRUCTURAL, CHEMICAL,
MECHANICAL AND
THERMAL ANALYSIS

XRD: crystallinity and phases present in the fibers, as well as lattice parameters, strain states and preferential orientations

Cryo -TEM/STEM : deeper study of the local microstructure of the scintillator materials and inclusions in the polymer nanocomposite fibers

SEM & AFM: morphology and surface characterization of the fibers

TEM/STEM, EDX and EELS : oriented growth of the inclusions inside the polymeric fiber matrix, imaging and chemical analysis of the different individual inclusion at the atomic scale, with high spatial resolution

RAMAN & INFRARED REFLECTIVITY: information on structural order, stress, and chemical state, before and after the radioluminescent incorporation in the nanofibers.

TGA & DSC: thermal stability.

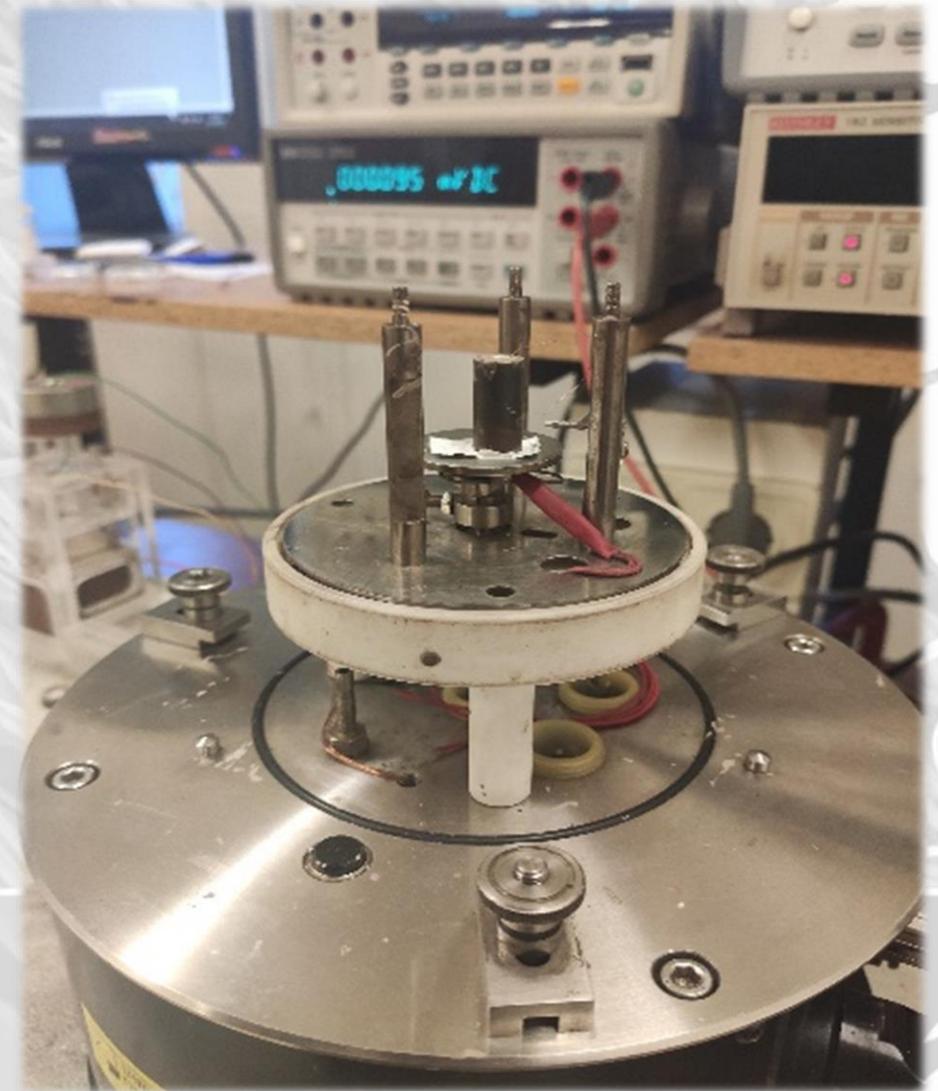
MECHANICAL PROPERTIES: dynamic mechanical analysis and uniaxial tensile testing

Research work plan

TASK 3

STUDY OF THE ELECTRIC
PROPERTIES OF THE
FIBERS

DIELECTRIC & CONDUCTIVITY :
measurements by impedance spectroscopy,
as a function of temperature and frequency



Research work plan

TASK 4

OPTICAL,
LUMINESCENT AND
NONLINEAR OPTICAL
PROPERTIES



OPTICAL ABSORPTION, DYNAMIC LIGHT SCATTERING AND PHOTOLUMINESCENCE:

investigation of the optical properties of the scintillators and electrospun composite fibers

NON-LINEAR OPTICAL SECOND HARMONIC

GENERATION (SHG) :information on the spatial distribution and crystal orientations of the fiber and on its non-linear-optical conversion capability.

Research work plan



TASK 5

ASSESSMENT OF THE
SCINTILLATION PROPERTIES
OF THE NANOFIBERS

Selected nanofiber samples with radioluminescent inclusions will be measured for scintillation using a photodiode/photomultiplier and an X-ray source. The aim is to create a flexible, wearable, and precise dosimeter with high sensitivity and energy/dose independence, exploring the role of nanoparticles and scintillators. This research seeks to develop new radiation detectors and personal dosimeter systems

Research timeline

Task	Task Denomination	Year 1												Year 2												Year 3												Year 4											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1	Synthesis radio electrospun single and composite fibers	[Blue shaded cells]																																															
2	Structural, chemical, mechanical and thermal analysis	[Blue shaded cells]																																															
3	Study of the electric properties of the fibers	[Blue shaded cells]																																															
4	Optical, luminescent and nonlinear optical properties	[Blue shaded cells]																																															
5	Assessment of the scintillation properties of the nanofibers	[Blue shaded cells]																																															
		M1												M2												M3												M4											
		1st Progress Report												2st Progress Report																								Thesis											

M1	<p><i>Electrospinning of Nanofibers</i></p> <p>By the end of the first year several sets of samples with promising electrical and optical results will have been characterized, leading to the beginning of the scintillation measurements.</p>
M2	<p>Beginning of scintillation measurements</p> <p>Control of the best experimental Electrospinning parameters involved in the nanofabrication of aligned scintillation nanofiber arrays.</p>
M3	<p><i>Scintillation nanofibers</i></p> <p>Quantitative measurements of the scintillation properties of nanofibers according to their composition will have been attained. From this point on the, the scintillator response of the combinations of polymer+inclusions will be optimized</p>
M4	<p><i>Assessment of results</i></p> <p>By the end of the project the PhD thesis will be delivered and a proof-of-concept prototype radiation detector will be delivered.</p>



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THANK YOU!