

Ankita Saikia, Costas Tzoganakis  
 Department Of Chemical Engineering, University of Waterloo  
 Waterloo, Ontario, Canada

## Background

- The increasing amount of scrap tire generation is accompanied by many environmental problems ;
- Scrap tires can be devulcanized and reused;
- The devulcanized rubber may have different characteristics than virgin rubber;

## Objectives

- To study the vulcanization reaction of devulcanized rubber by differential scanning calorimetry (DSC) ;
- To model the curing behavior of devulcanized rubber ;
- To compare the curing behavior of virgin rubber and devulcanized rubber.

## Experimental

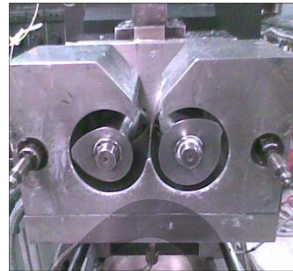
### 1. Mixing

Table1. Formulations					
Ingredients	Dosages (gm)				
	A	B	C1/C2/C3	D	E
Natural Rubber/ Devulcanized Rubber	200	200	200	200	200
Sulphur	1	5	3	1	5
*TBBS	1	1	3	5	5
Zinc Oxide	6	6	6	6	6
Stearic Acid	2	2	2	2	2

\*TBBS- N-tert-butyl-2-benzothiazyl sulfenamide

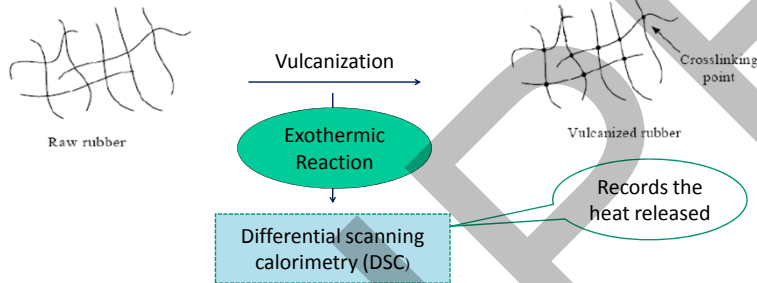


Rhinehart Tire Fire



Batch Mixer

### 2. Characterization; Differential Scanning Calorimetry (DSC)

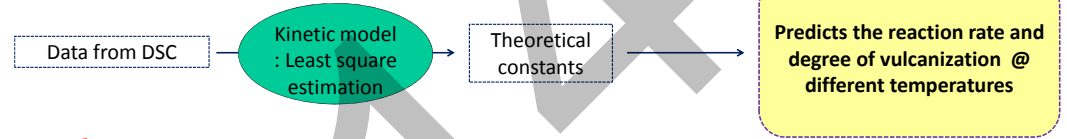


## Model equations and data fitting

### 1. Kinetic Models

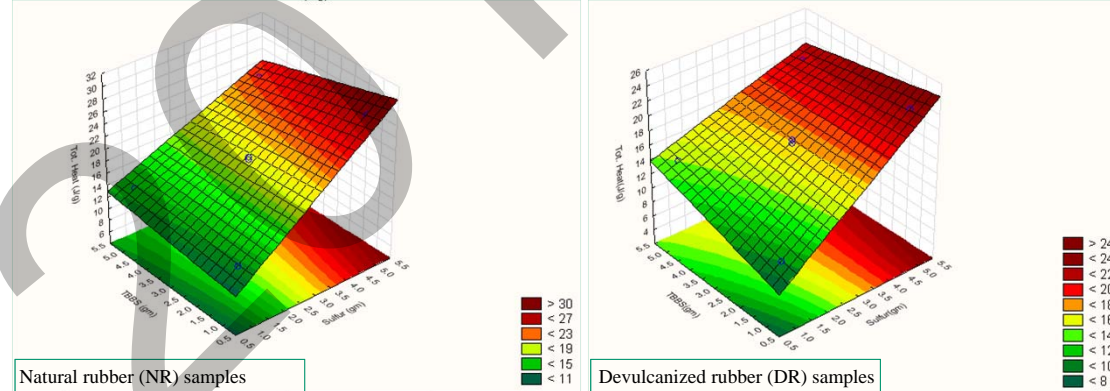
<u>Kissinger Model</u>	$dc/dt = k(1-c)^n$
<u>Arrhenius Model</u>	$k(T) = a \exp(-E/RT)$
<u>Kamal-Sourour Model</u>	$dc/dt = (k_1 + k_2 * c^m) * (1-c)^n$

### 2. Fitting of data

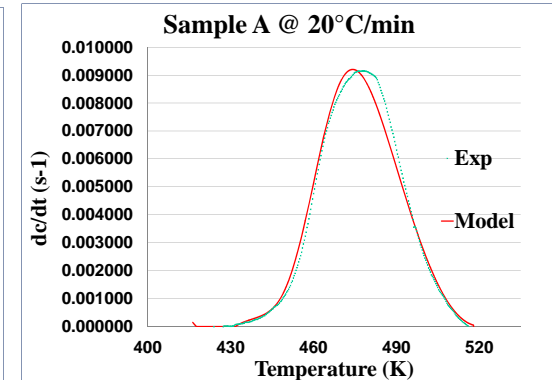
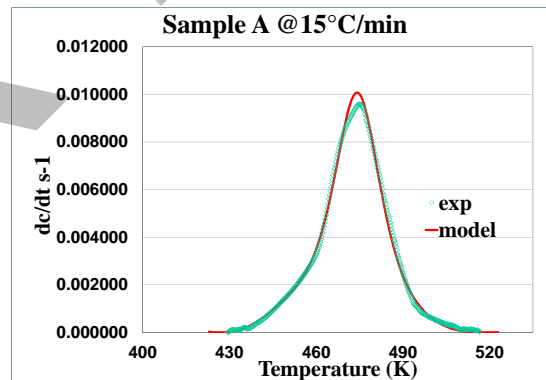


### Results

- Effect of change in curative composition in total heat of reaction



- Fitted model and experimental data at different scan rates



### Concluding Remarks

- The total heat of reaction is seen to be linearly proportional to the initial sulfur content;
- The total heat of reaction follows a similar trend for both natural and devulcanized rubber but the magnitude of the heat of reaction is less for devulcanized rubber samples compared to natural rubber;
- The fitted models are in good agreement with the experimental data, the constants obtained can be used to predict reaction rate and degree of vulcanization at different temperatures.