

# ANALYTIC RHEOLOGY

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## ABSTRACT

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The prediction of rheological properties using ‘double reptation theory’ of polydisperse branch chain polymers was investigated. High density polyethylene (HDPE) and low density polyethylene (LDPE) were used as model branched polymers. Polystyrene (PS) was selected as a standard linear polymer because the wealth of available data, and the lack of any long-chain branching. The rheological properties, storage modulus ( $G'$ ) and loss modulus ( $G''$ ), were measured by using a melt rheometer. The molecular weight distribution (MWD) was characterized by gel permeation chromatography (GPC). For PS, the double reptation model provides a good agreement with the experimental data in the terminal regime but a very poor agreement in high frequency regime. The discrepancy is due to lack of contour-length fluctuation, dynamic dilution, and Rouse relaxation process. For HDPE, the theory provides a good agreement with the experimental data in the frequency range between 1 – 100 rad/s. The long-chain branching causes a discrepancy in the low frequency regime. The prediction for LDPE fails in all range of frequency. The higher degree of long-chain branching in LDPE is found to cause more deviation in prediction in the prediction of rheological properties more than HDPE.

## บทคัดย่อ

พรรัชต์ ศิริประภารัตน์ : การศึกษาวิทยาการไหลของพอลิเมอร์ (Analytic Rheology)  
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การศึกษาผลของการใช้ ทฤษฎีคืบเบิลเรพเทชัน ในการทำนายคุณสมบัติการไหลของพอลิเมอร์ชนิดโพลีดีสเพอร์สแบบกึ่ง ซึ่งพอลิเมอร์ที่นำมาใช้ในการศึกษาเป็นพอลิเอทธิลีนชนิดความหนาแน่นสูงและพอลิเอทธิลีนชนิดความหนาแน่นต่ำ สำหรับพอลิเมอร์ที่ใช้เป็นมาตรฐานในการศึกษาคือ พอลิสไตรีน เพราะเป็นพอลิเมอร์ที่มีการศึกษากันอย่างกว้างขวาง และเป็นพอลิเมอร์ที่ไม่มีกิ่งที่ยาว ค่าคุณสมบัติการไหลของพอลิเมอร์, สโตเรจโมดูลัส และ ลอสโมดูลัส, สามารถวัดได้โดยใช้เครื่องเมทรีโอมิเตอร์ สำหรับค่าการกระจายของน้ำหนักโมเลกุลสามารถหาได้โดยใช้เครื่องเจลเพอร์มิเอชันโครมาโตกราฟี จากผลการศึกษาในพอลิสไตรีน พบว่าทฤษฎีคืบเบิลเรพเทชันสามารถทำนายผลได้สอดคล้องกับข้อมูลที่วัดได้จากการทดลองที่วัดในช่วงความถี่ต่ำ แต่ค่าที่ได้จะคลาดเคลื่อนเมื่อเปรียบเทียบที่ช่วงความถี่สูง ซึ่งค่าความคลาดเคลื่อนนี้อาจจะเป็นผลมาจากการที่ทฤษฎีนี้ไม่ได้รวมกลไกการเกิดคอนทัวร์เลนจ์ฟลักทูเอชัน, ไดนามิกไคลลัน, และเรจันรีแลกเซชัน สำหรับผลการทำนายของพอลิเอทธิลีนชนิดความหนาแน่นสูงนั้น ทฤษฎีกับผลการทดลองจะสอดคล้องกันในช่วงความถี่ระหว่าง 1 – 100 รอบต่อวินาที โดยผลของกิ่งที่ยาวของพอลิเมอร์ทำให้ผลที่ได้จากการทำนายคลาดเคลื่อนไปจากผลการทดลองในช่วงความถี่ต่ำ สำหรับการทำนายคุณสมบัติการไหลของพอลิเมอร์ในพอลิเอทธิลีนชนิดความหนาแน่นต่ำนั้น ทฤษฎีคืบเบิลเรพเทชันไม่สามารถทำนายได้ในทุกช่วงความถี่ ทั้งนี้เพราะปริมาณของกิ่งที่ยาวในพอลิเมอร์ชนิดความหนาแน่นต่ำที่สูงขึ้นนั้นจะส่งผลให้ค่าการทำนายคลาดเคลื่อนมากขึ้นกว่าในพอลิเมอร์ชนิดความหนาแน่นสูง

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